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Design of Multi Component Holding Fixture for Tibial Insert in Knee Transplant

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Abstract

Fixture is a work holding device which is necessary at every stage of manufacturing process. From simple machining operation to fabrication and inspection, the work piece has to be held in position firmly and rigidly. The part taken for work is a medical component named Tibial Insert used in knee transplant. There are about fifty four types of tibial insert manufactured in the company. From the study on existing methodology of manufacturing it was clear that little changes could be done in the machining of the part but by changing the holding device better results can be achieved. Hence the work was targeted in designing of the fixture. For more efficient outcomes the fixture is designed for accommodating eight components and machining of eight components can be done in one go. The designing is done using the Autocad and SolidWork software

Keywords: : *Fixture, Modular Fixture, Dedicated Fixture, Tibial Insert.*

1. Introduction

In manufacturing industry, the introduction of Flexible Manufacturing System has given significant results such as high productivity, high quality, and low-cost production and reduced cycle time. “FMS can be defined as highly flexible production unit capable of producing a range of discrete products with a minimum of manual intervention”. FMS consists of CNC machines, industrial robots, inspection units and other equipment integrated with automatic material handling and storage systems. The fundamental of all these process is proper holding of workpiece at every stage. Although there are much advancement in the field of machine tools, cutting tools and production methods, the basic concept of holding the workpiece has seen very little changes. Whatever is the operation like simple drill or machining or joining or inspection the part should be accurately located and securely held throughout the operation. Like all the required operations cannot be performed in a single machine tool, every part cannot be held in a single work holding devices. And hence fixture design is necessary and is ever changing for every part.

2. Literature Review

Detailed description on the need of fixture and the steps required for designing the fixture are mentioned in this paper. The principle of location and guidelines for locating and different methods used in location are also explained. Similarly the principle of clamping and types of clamping methods are discussed [1].One way to reduce the production cost is to reduce the use of single purpose process equipment which makes way for universal process equipment. A suitable solution can be achieved by using automatic replacement of clamping jaws depending on the types of workpiece being clamped [2]. The design of fixture for the component yoke gave a foundation in designing the fixture for tibial insert. The fundamental requirements of location and clamping are achieved by collet, stoppers and v blocks. 8 cylinder hydraulic fixtures can accommodate 4 yokes. The manufactured 8 cylinder fixture has the provision for expanding customized collet [3]

3. Component Description

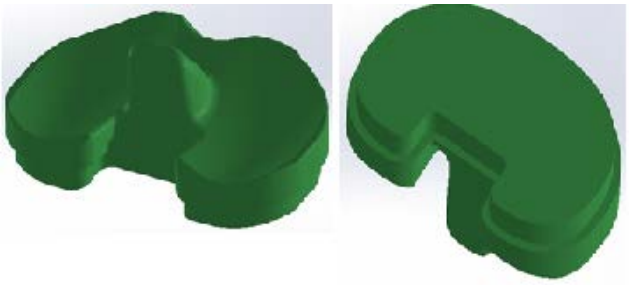

Figure 1: Top and Bottom View of Tibial Insert

Tibial insert plays an important role in total knee implant. It is the intermediate component between the femoral and the tibial plate. It functions to provide smooth movement of femoral against it and also wears out minimally because of its plastic material. In many cases, it replaces the worn out cartilage meniscus present in between the femur and

tibia. Tibial insert is fabricated using biocompatible biomaterials according to standards usually of ultra-high molecular weight polyethylene (UHMWPE). The Tibial insert is grouped into four major categories namely, INDUS INSERTS, TRIAL INSERTS, GENIUS INSERTS and GENIUS TRIAL INSERTS. The Indus insert is available in five sizes, small, medium, medium plus, large and large plus. And under each sizes there are four components varying in the thickness. So all together there are twenty types in the Indus inserts. Similarly to Indus inserts the Trial inserts has twenty types. The Genius insert is available in seven sizes, size_A12, size_A34, size_BCDE_12, size_BCDE_34, size_BCDE_56, size_BCDE_7, size_FGH_7 and size_FGH_56. Similar to Genius inserts the Genius trial insert has seven types. To sum up there are fifty four components of the same family.

4. Objectives

The objective of designing the multi component holding fixture for Tibial inserts is to optimize the production process. Optimization of production process results in increase in productivity, reduction in setting time, efficient utilization of the machine capacity, reduction in production cost, can be operated by unskilled operators, accuracy in machining process can be achieved and quick change over time from job to job.

In addition to the primary objective above stated,

[1] The design must be of low cost.
[2] The design should be safe.
[3] The design should be simple to handle and operate with minimum human effort.

5. Guidelines for Fixture Design

A fixturing system consists of three basic types of elements: locators, clamps, and supports. Locators are used to position the workpiece in a state of static equilibrium, depriving the workpiece of its twelve degrees of freedom. Clamps are for keeping the workpiece firmly against the locators and holding it there against the action of cutting forces. In addition to locators, supports are sometimes needed to control deflection of the workpiece due to its own weight, tool forces and clamping forces. The fixture must accomplish the following objectives:

(a) Steady positioning of the workpiece in relation to the tool.
(b) Holding the desired position of the workpiece against tool forces.
(c) Limiting deflection of the workpiece due to cutting forces.

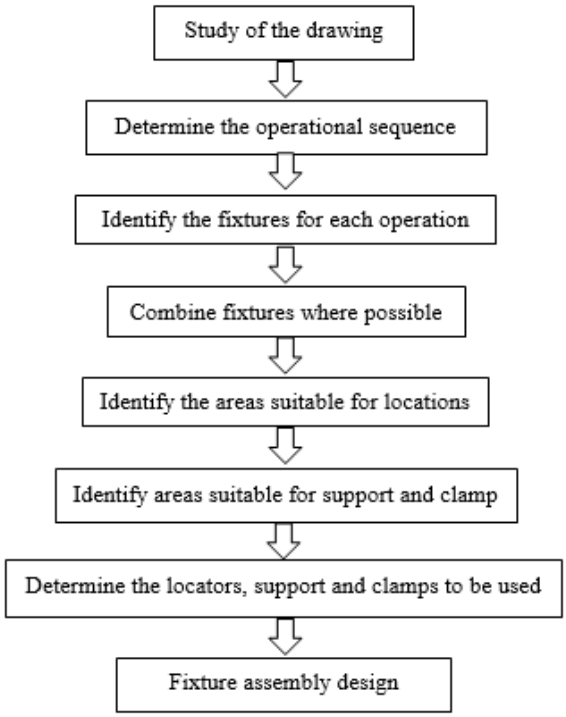

Figure 2 Flow Chart for Fixture Design

6. Design of Fixture

On studying the drawing of tibial insert it requires three sequences of machining operation for completing the part. The raw material is a rectangular block. For ease of location and clamping throughout the machining process three M8 tap is done on to the rectangular block.

6.1 I Operation

I operation is the machining of the top view profile with concave surface and the angular projection. Since the raw material is the rectangular block containing three tap holes, a simple baseplate an element of modular fixture can be used as the fixture. The tap holes can be used as locating points and M8 screws can be used to clamp the rectangular block on to the fixture. The fixture can be clamped to the vertical machining centre using T bolt. Eight rectangular blocks are clamped on the base plate as shown in the figure below.

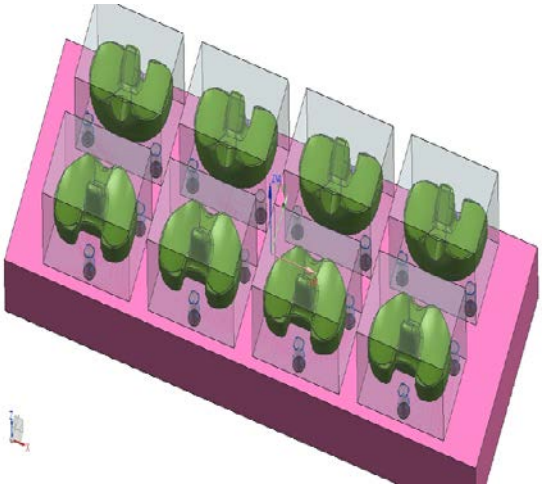

Figure 3: Base Plate as Fixture for Operation I

6.2 II Operation

II operation is the machinig of the angular projection. This requires a separate machining as the angle is in negative draft. After the I operation the base plate is clamped to the angle plate as the orientation of the machining is 90º to the I operation. The angle plate is clamped to the machine using T bolt.

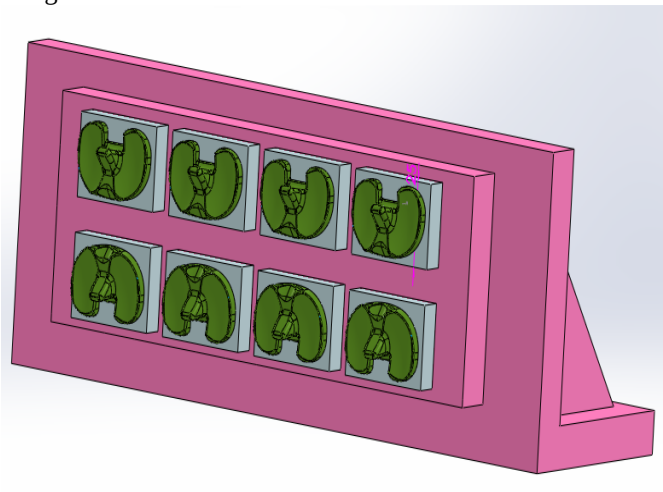

Figure 4: Angle Plate as Fixture for Operation II

6.3 III Operation

III operation fixture is a dedicated fixture. The clamping area for III operation is the circular profile, hence the fixture contains the profile matching the part. Since the third operation is to machine the bottom surface, the fixture has the pocket to accommodate the height of the angular projection. The fixture also has the provision for the wedge clamping method. Since the fixture has to be designed for all the sizes of the tibial insert, part of the profile of the component is designed in the fixture which is fixed and the rest of the part in the wedge clamp as it is adjustable. By this way the fixture can be used for all the components of the tibial family. The design of the fixture is shown in the figure below.

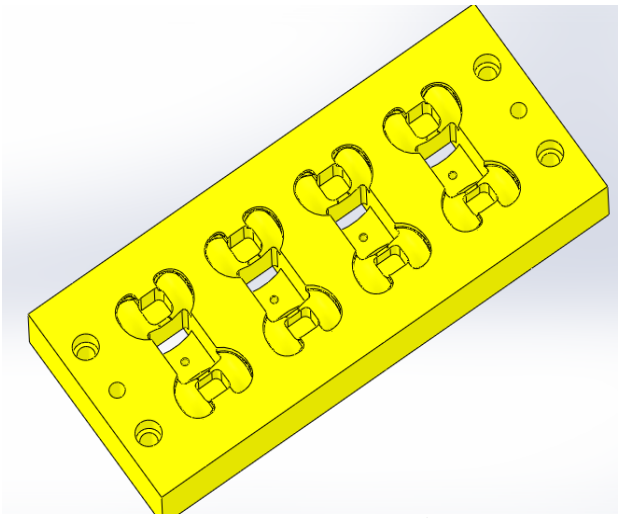

Figure 5: Dedicated Fixture for Operation III

Wedge clamp apply the basic principle of the inclined plane to hold work in a manner similar to cam. These clamps are normally found in two general forms, flat wedges and conical wedges. A plain wedge clamp consists of a movable inclined plane, the clamping jaws which forces the work piece against a fixed stop. These clamps tend to loosen under vibration. The taper end of the plain wedge ranges from 6-8 degree depending upon the coefficient of friction of the metal. Since they will not hold by themselves, another device such as cam or screw must be used to hold them in place. Here the screw is used passing through the centre causing the clamp to wedge the work in position. Provided the spring tension between the L block and the clamping jaws helps in easy removal of the part from the clamp as loosening the wedge. Here, by using one wedge clamp two parts can be clamped at one time. The clamping jaws takes the shape of the part which butts the part easily into the fixture.

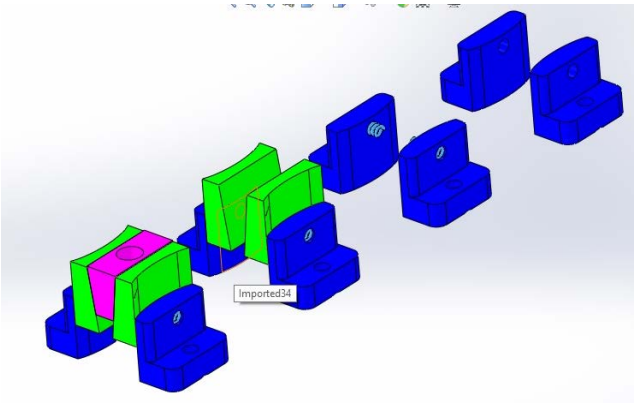

Figure 6: Elements of Wedge Clamp

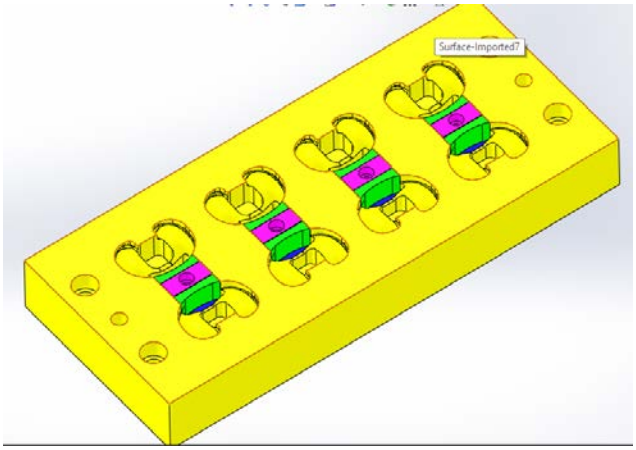

Figure 7: Assembly of Fixture with Wedge Clamp

7. Conclusions

By using the multi component holding fixture, which can machine eight components in one setting, the cycle time for eight components is reduced when compared to machining eight individual components. The location and clamping is much easier that the setting time is considerably reduced. In the third operation the design of wedge clamp is such that two components are clamped at a time. Decrease in cycle time increases the productivity.

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