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Design Tapping Fixtures for Aluminium Die Casting Body in Petrol Pump

B.Maharajan, Dr.S.Balasubramanian

Abstract-**Fixture in tooling industry contributes more to improve economy of production. It ensures quality and quick transition of parts. A novel design on a fixture for tapping holes for complicated profile petrol pump body made of aluminium die casting material. The fabricated fixture used for trials. The time study conducted with samples and the results we compared with manual cycle time. Improvement in reduced cycle time shown 50% and the rejection quantity due to unmatured threads, shifting of axis and end damage are reduced 1/50 batch. Fixtures like this can adopt to the mass production components in automobile, Aeronautics and manufacturing units.**

Keywords-**fixtures, aluminium, tapping, production**

I. INTRODUCTION

Engineering components produced in manufacturing industry are assured for quality issues.In metal removing process the workpiece to be hold firmly on the bed of machine. The fixture plays a vital role to fix quality, quantity and cost in production.

Fixtures are used to hold the work piece during machining operations. The name is derived from the fact that a fixture is always fixed or fastened to a machine in the fixed position. It does arrangements for support jig and guiding the tool. The use of fixture becomes essential. When the components to be produced are in large number.

There are many number of fixtures used in different industries for different types of work pieces. But generally they are classified on the basis of their working operations in different machine tools. In a setup using a fixture the responsibility for accuracy depends upon the operator and the construction of the machine tool.

Here we are design a fixture for tapping operation on casted holes. The operation of tapping is done in a drilling machine with gang tapping attachment. Here the body of the petrol pump made of aluminium casting has six drilled holes; manually it is made by six times of moving and setting the tool. The non fixture takes $1/6^{th}$ of time of manual.

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B.Maharajan, Department of Mech. Engineering, SNS College of Engineering, Coimbatore, India, Mobile +91-9865108316.
Dr.S.Balasubramanian, Department of Mech. Engineering, SNS College of Engineering, Coimbatore, India, Mobile +91-9443506760

A. Steps of fixture design

Fixture design begins with a successful logic and systematic plan. Fixture functional requirements with a complete analysis, it occurs very few design problem. The workpiece tooling, processing and machine tool may affect the extent planning needed. Preliminary analysis may take from a few hours up to several days for more complicated fixture designs. Fixture design can be done in five steps for problem solving process.

Step.1 Define requirement

To initiate the fixture design process, state the problem clearly to be solved. State these requirements as broadly as possible, but specifically enough to define
Scope of the design project. The designer should ask some questions themselves that is the new tooling required first time production or improve existing production?

Step.2 Gather / Analysis Information

Collect all relevant data and assemble it for evaluation. The main source of information are the part print, process sheet and machine specifications. Make sure that part documents and records are current. With these notes they should be able to fill in all items on the checklist for design considerations. All ideas, thoughts, observations and any other data about the part fixture are then available for later reference. It is always better to have too many ideas about the part or fixture are then are available for later considerations need to be taken into account. For design considerations need to be taken into account.

Step.3 Develop Several Options

This of fixture design process requires the most creatively. A typical work piece can be located and clamped several different ways. The natural tendency is to think of one solution, then develop and refine it while blocking path right away. A designer should brainstorm for several good tooling alternatives, not just choose one path right away. During this phase the designers' goal should be adding options not discarding them. The more standard locating and clamping devices that a designer is familiar with the more creative. Areas for locating part include flat exterior surfaces.

Step.4 Choose the Best Option

The total cost to manufacture a part is the sum of per piece run cost, setup cost, and tooling cost. Expressed as a formula:

$$\text{Cost per part} = \text{Run cost} + \frac{\text{Setup cost}}{\text{Lot size}} + \frac{\text{Tooling cost}}{\text{Totalquality over tooling life time}}$$

Step.5 Implement the design

The final phase of the fixture design process consists of turning the chosen design approach into reality. Final details are decided, final drawings are made and the tooling is built and tested. The following guidelines should be considered during the final design process to make less costly while improving its efficiency.

B. Important Consideration While Designing Fixtures

Designing of fixtures depends upon so many factors. These factors are analyzed to get design inputs for fixtures. They are given below:

a. Study of work piece and finished component size and geometry.
b. Type of capacity of the machine, its extent of automation.
c. Provision of locating devices in the machine.
d. Available clamping arrangements in the machine.
e. Available indexing devices their accuracy
f. Evaluation of variability in the performance results of the machine.
g. Rigidity and of the machine tool under consideration.
h. Study of ejecting devices, safety devices etc.
i. Required level of the accuracy in the work and quality to be produced.

C. Meaning of Location

The location refers to the establishment of a desired relationship between the workpiece and the fixture correctness of location directly influences accuracy of the finished product. The fixtures are desired so that all undesirable movements of the workpiece can be restricted. Determination of the locating points and clamping of the workpiece serve to restrict movements of the component in any direction, while setting it in a particular pre-decided position relative to jig. Before deciding the locating points it is advisable to find out all possible degrees of freedom of the work piece. Then some of the degrees of freedom or all of them are restrained by making suitable arrangements. These arrangements are called locators.

D. Principles of Locations

In the design of jigs and fixtures, the location of the component is very important aspect to influence this accuracy of the finished product. The locating device should be designed such that each successive work piece when loaded and clamped will occupy the same position in the jig or fixture. The selection of work holding device mainly depends on the nature of workpeice and requirement of the machining operation. Some of the principles to be followed for location of a workpiece are explained below.

Consider a work piece placed free in space. Anybody in this condition has six degrees of freedom. Three of these freedoms are translation and remaining is rotation with respect to three mutually perpendicular axes is shown in fig.1.

The three freedoms of translations are:

(i) Move along ‘X – X’.
(ii) Move along ‘Y – Y’.
(iii) Move along ‘Z – Z

Three freedoms of rotation are:

(i) Rotate about ‘X – X’.
(ii) Rotate about ‘Y – Y’.
(iii) Rotate about ‘Z – Z’.

Thus, six degrees of freedom are obtained

To locate a work piece accurately, it is necessary to restrict it against movements in any of the six degree of freedom with the help of suitable locating pins.

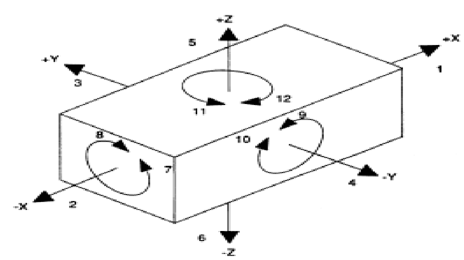

Fig.1 Principle of location

E. Different Methods used for Locations

There are different methods used for location of a work. The locating arrangement should be decided after studying the type of work, type of operation, degree of accuracy required. Volume of mass production to be done also mattes a lot. Different locating methods are described below;

Flat Locator

Flat locator is used for location of flat machined surfaces of the component. A flat surface locator can be used as shown in figure. In this case an undercut is provided at the bottom where two perpendicular surfaces intersect each other. This is made for Warf clearance. It is used to locating components having drilled holes are shown in fig.2.

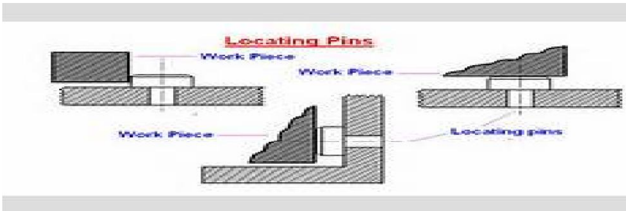

Fig.2 Flat locator

Jack Pin Locator

Jack pin locator is used for supporting rough work pieces from the shown in figure. Height of the jack pin is adjustable to accommodate the work piece having variation in their surface texture. So this is a suitable method to accommodate the components which are rough and machined are shown in fig.3.

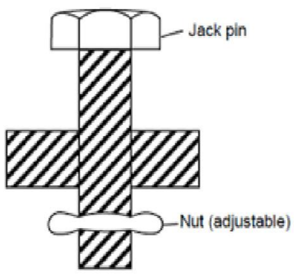

Fig.3 Jack pin locator

Drill Bush Locator

The drill bush locator is used for holding the cylindrical work pieces. The bush has conical opening for locating purpose and it is sometimes screwed on the jigs body for the adjustment of height of the work are shown in fig.4.

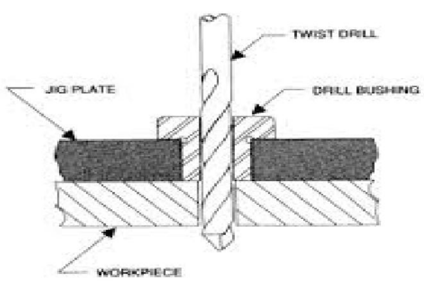

Fig.4Drill bush locator

Vee Locators

This is quick and effective method of locating the workpiece with desired level of accuracy. This is used for locating the circular and semi circular type of workpiece. The main part of locating device is Vee shaped block which is normally fixed to the jig. This locator can be of two types fixed Vee locator and adjustable locator can be moved axially to provide proper grip of Vee band to the workpiece are shown in fig.5.

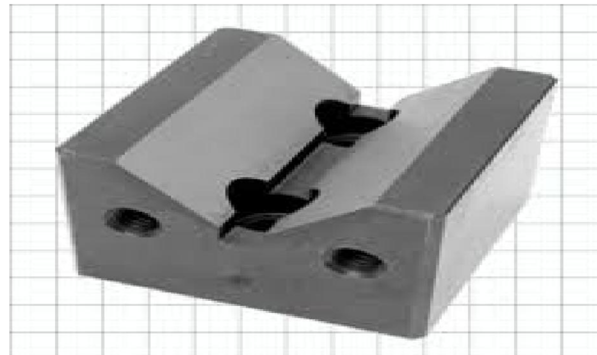

Fig.5 Vee locator

F. Clamping

To restain the workpiece completely a clamping device is required in addition to locating device and jigs and fixtures. A clamping device holds the workpiece securely in a jig or fixture against the fores applied over it during on operation. Clamping devices should be incorporated into the fixture, proper clamp in a fixture directly influence the accuracy and quality of the work done and production cycle time.

G. Different Methods of Clamps

Strap Clamp

This is also called edge clamp. This type clamping is done with the help of a lever pressure acting as a strap on the workpiece. Different types of strap clamps are discussed below and one of the strap clamp is shown in fig.6.

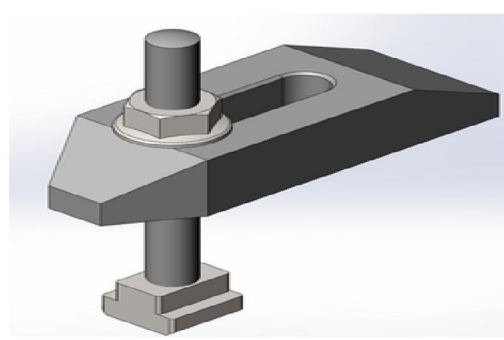

Fig.6 Strap clamp

Heel Clamp

Rotation of the clamp is clockwise direction is prevented and it is allowed in anticlockwise direction. For releasing the work piece the clamping unscrewed.

The free movements in anticlockwise direction take place before un securing the nut to release the work piece are shown in fig.7.

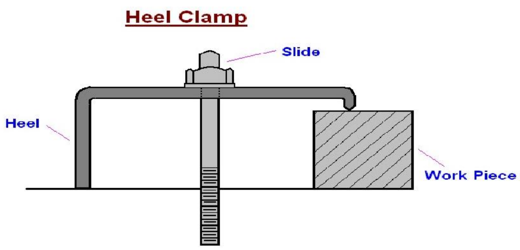

Fig.7 Heel clamp

Bridge Clamp

The bridge clamp applies more clamping pressure as compared to heel clamp. The clamping pressure experienced by the work piece depends on the distance 'x' and 'y' marked. To release the work piece the nut named as clamping nut is unscrewed. The spring lifts the lever to release the work piece are shown in fig.8.

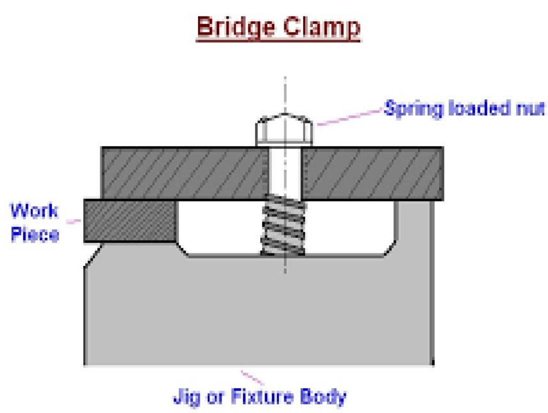

Fig.8 Bridge clamp

Edge Clamp or Side Clamp

A side clamp is also known as edge clamp. In these cases the surface to be machined is always clamped above the clamping device. This clamping device is recommended for fixed length work piece. This clamping device is recommended for fixed length work piece. Releasing and clamping of the work piece can be accomplished by unscrewing and screwing of the clamping nut respectively are shown in fig.9.

Fig.9 Edge clamp or side clamp

Screw Clamp

The screw clamp is also known as clamp screw. This clamping apply pressure directly on the side faces of the work piece are shown in fig.10.

Fig.10 Screw clamp

Latch Clamp

Latch clamp are used to clamp the work piece, the clamping system is normally locked with the help of latch provided. To unload the work piece the tail end of the latch is pushed that causes the leaf to swung open, so releasing the work piece. Here the consumed in loading is very less as no screw is tightened but clamping pressure is not so high as in other clamping devices are shown in fig.11.

Fig. 11 Latch clamp

Equalizing Clamp

Equalizing clamp is recommended to apply equal pressure on the two faces of the work. The pressure applied can be varied by tightened or loosening the screw provided for the purpose are shown in fig.12.

Fig.12 Equalizing clamp

Power Driven Clamping

Light duty clamps are used manually because small power is required to operate these clamps. Hand clamping leads to application of variable pressure, operators fatigue and more time consumed. The power driven clamping over comes the above mentioned problems of hand clamping. Power clamps are operated on the base of hydraulic or pneumatic power. Power clamps are high pressure clamping, these are quick acting, easily controllable, reliable and less time consuming. It is shown in fig.13.

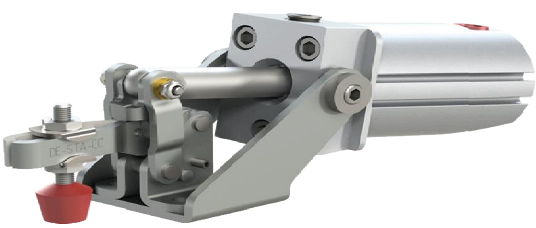

Fig.13 Power driven clamp

II. LITERATURE SURVEY

1. Shailesh S. Pachbhai, Laukik P. Raut (2014) have described that in machining fixtures, minimizing work piece deformation due to clamping and cutting forces is essential to maintain the machining accuracy. This can be achieved by selecting the optimal location of fixturing.
2. Chetankumar M. Patel, Dr. G. D. Acharya (2014) have discussed that Paper proves utility of hydraulics in fixture design in three different ways: (i) reduces cycle time, (ii) reduces operator fatigue and increases productivity and (iii) reduces wear and tear of fixture components.
3. In contrast to concentration of six axis nano positioning method Dr.Patrick J. Golden (2013) tested a unique dovetail fretting fatigue fixture was designed and evaluated for testing turbine engine materials at room or elevated temperatures. Initial test results revealed interesting variability in the behaviour of the nickel based super alloy specimens at elevated temperature.
4. K.C. Aw (2013) paper concentrates on electronic equipment used for maritime application. Simulation using ANSYS workbench software was performed to comprehend the effect of various parameters of accelerated testing performed on these waterproof enclosures. Experiments were performed to examine the correlation with simulation results. The above mentioned strategy was applied to reduce the buckling in a part of fixture design assembly.
5. T. Papastathisa, O. Bakkera , S. Ratcheva, A. Popova (2012) have described that instead of using passive fixture element use active fixture element because it reduce the dynamic deformation of the work piece by 84.2%.
6. The study of Dr. Yu Zheng (2008) presents a method for finding form-closure locations with enhanced immobilization capability. Fixtures are used in many manufacturing processes to hold objects. Fixture layout design is to arrange fixturing elements on the object surface such that the object can be held in form-closure and totally immobilized.
7. The research of closure locations was determined experimentally by Kartik (2007) as it focusedon the kinematics, stiffness, repeatability of a moving groove and dual-purpose positionedfixture. A dual-purpose positioned fixture is an alignment device that may be operated in a fixture mode or a six-axis nano-positioning mode..
8. Mervyn (2003) addresses the development of an Internet-enabled interactive fixture design system. A fixture design system should be able to transfer information with the various other systems to bring about a seamless product design and manufacturing environment. Thus a great amount of experience of fixture design is wasted and cannot be re-used, which reduces design efficiency and violates the t intention of case-based reasoning methods. In order to realize agility of fixture design, including re-configurability, re-scalability and re-usability.

.Many of the researchers done a fixture for variety of methods such as welding, turning, drilling, honing, assembly etc, except tapping for mass production components. We proposed a special fixture for gang tapping of aluminium components.

III. PROBLEM FORMULATION

The problem related to reduction of time in production in tapping operation will be discussed in detail is given below.

- The main problem to reduce the time in mass production.
- To reduce the number of stroke of the tool moving.
- To reduce the setting time according to the worker skill.
- To improve the quality of the product.
- To reduce the rejection quantity of the product.
- To reduce the loading and unloading time.
- Here the industry faces lot of problem for handling the aluminium component for tapping.
- The company has faced more problems in production to give good quality products and to minimize the rejection of quality.

So to overcome these problems, it is proposed and design develops a fixture which will possibly reduce the entire problem.

IV. COMPONENT DETAILS

In industries tapping fixture is manufactured according to application requirement. For this fixture all input data explained in above design procedure is collected.AIS140material is selected for design. Side plate, bottom plate, holder, component holder, locking pin, lockets pin, stud and nut. The component located on the side plate on the side plate with reference of 90mm diameter on the body is shown in fig.14. For steadiness it is clamped at centre with a nut.

The tapping fixture is shown in below figure. The fixture is look like 'L' shape structure. It consist of side plate which was machined a groove for a component to seat at the area and it was also hardened to reduce the wear and to produce large number of quantity. Here we can arrest the component with the bottom plate to reduce vibration and it can be locked with the holder, component holder, locking pin, stud and nut. In the second operation tilt the 'L' shape fixture for tapping the final two holes. The assembly drawing of a fixture is shown in fig.15.

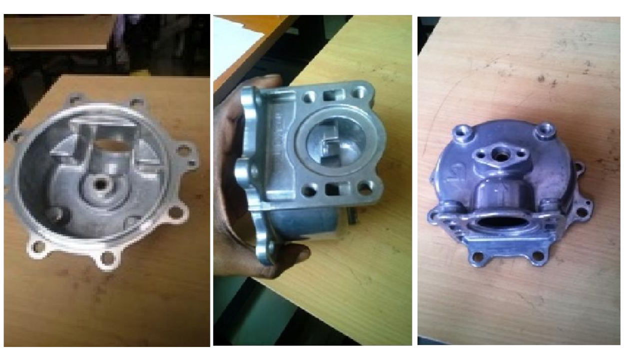

Fig.14: Aluminium body

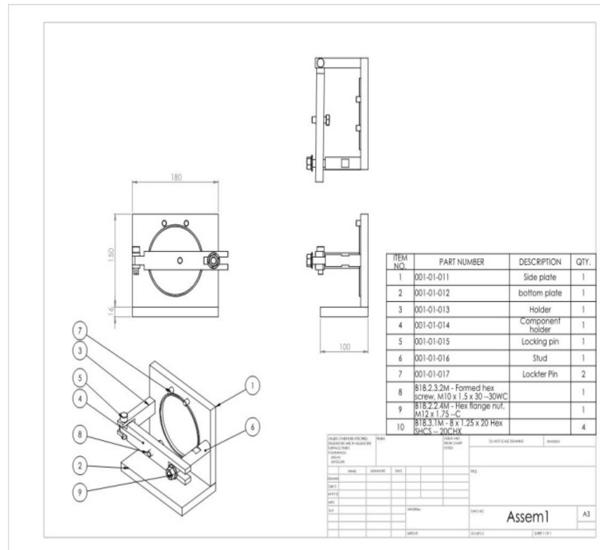

Fig.15 Assembly of fixture

V. CYCLE TIME ESTIMATION

The design of fixtures should be such that the process of loading and unloading the components takes the minimum possible time and enables on easy loading. Here the fig.16& 17 showing the fixture in open and close position. The fig.18 shows the tapping operation - 1 and the fig.19 shows the tapping operation – 2. The fig.20 shows the cycle time for tapping by manual Vs fixture.

Table 1: Cycle time estimation

Operation	Manual	Fixture
Clamping time	10secs	5secs
Tapping time (6 holes/6 times)	60secs	
Tapping time (6 holes/3 times)		30secs
Unclamping time	10secs	5secs
Cleaning time	10secs	5secs
Total cycle time	90secs	45secs

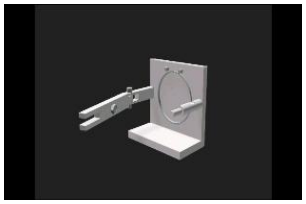

Fig.16 Fixture in open clamp position

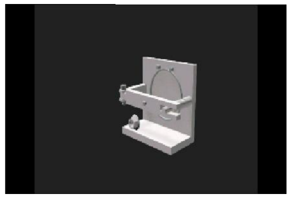

Fig.17: Fixture in closed clamp position

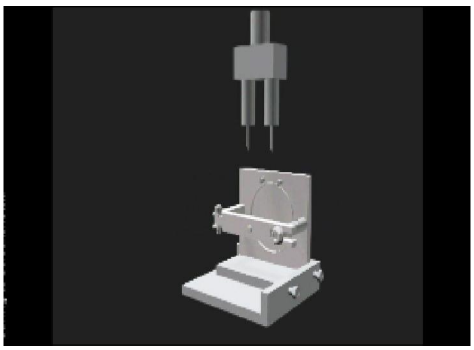

Fig. 18: Tapping operation - 1

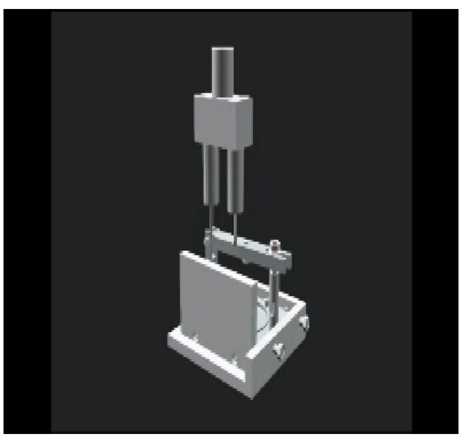

Fig.19: Tapping operation - 2

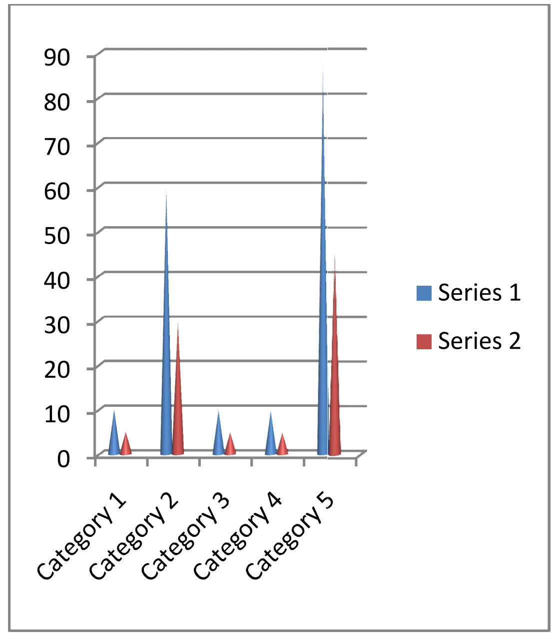

Fig.20; Cycle time for tapping by manual vs fixture.

VI. RESULTS AND DISCUSSION

The flexibility of fixtures plays an important role in reducing machining costs and times in manufacturing industries.

Fixture design explained in this paper can help to improve productivity and accuracy of machining significantly, lowering the time and skill level needed.

1. In the previous method tapping operation is manually done in six drill holes and put tap in by making setting for individual hole for six time. It is done by new fixture method called gang tapping fixture and the operation of tapping is done by three times.
2. Due to new tapping fixture are exactly located, supported and clamped which reduces the machine setting time, hence the productivity time increased by 50% and also increase in accuracy and process control.
3. In the previous method due to clamping aluminium component in vice can damage the body and the holes are not aligned as through holes and lot of piece may be rejected.
4. Rejection rate reduced to less than 2% in this fixture comparison to 15% of individual tapping, because new tapping fixture gives uniform clamping and reduced vibration.
5. For this new tapping fixture coolant oil (kerosene) is used to cooling the threaded area and to remove small metal particles of machining.

6. The rejection quantity due to unmatured threads, shifting of axis and end damage are reduced 1/50 batch.

VII. CONCLUSION

The efficiency and reliability of the fixture design has enhanced by the system and the result of the fixture design has made reasonable. To reduce cycle time required for loading and unloading of part, this approach is useful, SOLID WORKS are used in designing the systems then significant improvement can be assured. To fulfil the multifunctional and high performance fixturing requirements optimum design approach can be used to provide comprehensive analysis.

VIII. ACKNOWLEDGEMENT

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