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Design, Modification and Analysis of a Fixture used for Assembly of Steering Knuckle and Stub Axle

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Abstract: Fixture is design and develops to locate, hold and support a component during a manufacturing operation. In modern manufacturing processes, fixtures are most essential elements of production processes which aim to achieve high productivity ultimately by reducing unit cost. Simply, fixture increases rate of loading and unloading, resulting in considerable saving in set-up time. By considering benefits of fixture in modern manufacturing, this work aims to study of existing system and thereby make desirable design modifications in it. This leads to Design, CAD drawing preparation by CATIA, analysis by ANSYS, manufacturing and implementation of the same. Paper also focuses on basics of locating principle and components of fixture. Thus, all efforts finally sum up to reduce the labor fatigue, assembly time and minor stoppage and ultimately enhance the productivity.

Keywords: Fixture, Fixture Plate, Wing Bolt, Minor Stoppages, Assembly Time, Productivity.

I. INTRODUCTION

A fixture is a device used to locate, hold and support a component during a manufacturing operation. It becomes an essential element of production processes as it preferred in most of the modern manufacturing, inspection, and assembly operations. Fixture eliminates individual marking, centering and correct positioning of work before machining operation starts, it resulting in considerable saving in set-up time. So with ease of loading and unloading of work it improves production rate with accuracy as well. Over the past experience, manufacturing has made considerable progress. New cutting machine tools and modern manufacturing approach enable today's industries to make parts faster and better than ever before. Therefore the work holding methods have also advanced considerably, whereas the basic principles of clamping and locating are still same. This work uses same 3-2-1 principle of location for designing of fixture also uses ANSYS for analysis.

A. Steps used in Fixture Design

- 1) **Step 1:** Define Requirements To initiate the fixture-design process, clearly state the problem to be solved. Here, the basic requirement is design and modify the existing system. As existing system fails in achieving time constraint / cycle time required per assembly. This work aims to reduce the cycle time required for assembly of steering knuckle and stub axle.
- 2) **Step 2:** Gather/Analyze Information Collect all the data related to the existing system, find out the modes of problems, present them in the form of cause and effect diagram, analyse individually and work on the same.
- 3) **Step 3:** Develop Several Options This phase of the fixture-design process requires more hard work and creativity. For typical workpiece clamping and locating we had develop and work on several options. Each option gone through many factors viz. availability, ease of design, material selection, strength, cost etc. This actually brainstormed us a lot.
- 4) **Step 4:** Choose the Best Option Among several options, best appropriate option is selected to work on. Again during this selection we considered many factors including material selection, machining and setup cost etc.
- 5) **Step 5:** Implement the Design The final phase of the fixture-design process consists of implement the chosen option into reality. Accordingly required details are gathered, final drawings are prepared, and the tooling is built and tested.

B. Component of Fixtures

- 1) **Locators:** A locator is usually a fixed component of a fixture. It is used to establish and maintain the position of a part in the fixture by constraining the movement of the part. For workpieces of greater variability in shapes and surface conditions, a locator can also be adjustable.
- 2) **Clamps:** A clamp is a force-actuating mechanism of a fixture. The forces exerted by the clamps hold a part securely in the fixture against all other external forces.

- 3) *Supports*: A support is a fixed or adjustable element of a fixture. When severe part displacement/deflection is expected under the action of imposed clamping and processing forces, supports are added and placed below the workpiece so as to prevent or constrain deformation. Supports in excess of what is required for the determination of the location of the part should be compatible with the locators and clamps.
- 4) *Fixture Body*: Fixture body, or tool body, is the major structural element of a fixture. It maintains the spatial relationship between the fixturing elements mentioned above, viz., locators, clamps, supports, and the machine tool on which the part is to be processed. [4]

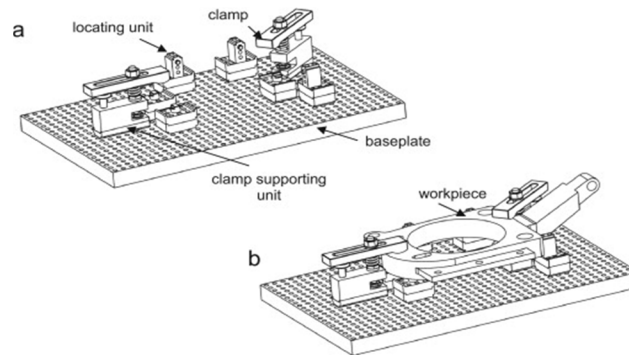


Figure 1.2: Components of typical fixture (a) without and (b) with a workpiece [2]

C. [3-2-1] Locating Principle

- 1) Accurately position the part at the desired coordinates.
- 2) Restrict all six degrees of freedom so that the part cannot move.

A widely used method of accomplishing these two objectives uses the 3-2-1 principle, so-called because it entails three steps that employ three, then two, then one fixed points of known location. Since that adds up to six fixed points, it's also known as the six point method.

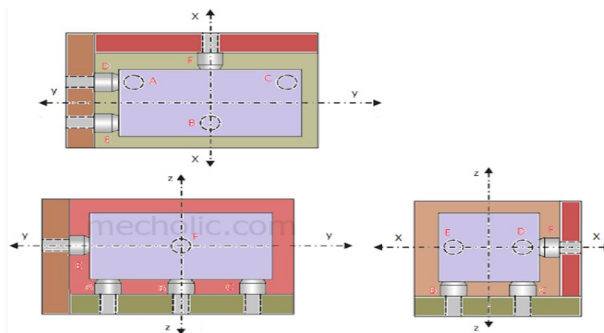


Figure 1.3: [3-2-1] Principal for fixture locator [give reference paper number]

In the three steps of the 3-2-1 method, three mutually perpendicular planes, called datum planes, are introduced, one at each step. These three planes define the workpiece position, and together with opposing clamping forces fully constrain the part. Let's take a look at the details of the 3-2-1 method.

- a) Six Points Location of a Rectangular Block Considering the six degree of freedom of a rectangular block as shown in Figure It is made to rest on several points on the jig body.
- b) Provide a rest to workpiece on three points on the bottom x-y surface.
- c) This will stop the movement along z-axis, rotation with respect to x-axis and y-axis.
- d) Supporting it on the three points is considered as better support then one point or two points.
- e) Rest the workpiece on two points of side surface (x-z), this will fix the movement of workpiece along y-axis and rotation with respect to z-axis.
- f) Provide a support at one point of the adjacent surface (y-z) that will fix other remaining free movements.
- g) This principle of location of fixing points on the workpiece is also named as 3-2-1 principle of fixture design as numbers of points selected at different faces of the workpiece are 3, 2 and 1 respectively.

II. STUDY OF EXISTING SYSTEM

A detailed study of an existing system was carried out, resulting in number of key points to be further considered while designing proposed fixture. Discussion on the same is made here.

In the current assembly line at one station of assembly there were one sort of fixture, clamping arrangement provided for assembly of steering knuckle and stub axle. In that traditional fixture, operator has to fasten or loose the allen bolt manually for the sake of loading/unloading of component, which required more setup time. Also operator uses DC tool for the same, where again inappropriate torque leads to stress concentration problem and wear of the fixture plate. Thus this approach fails to achieve target of assemblies per shift due to more setup time. And it seems to be an opportunity for further modification and development.

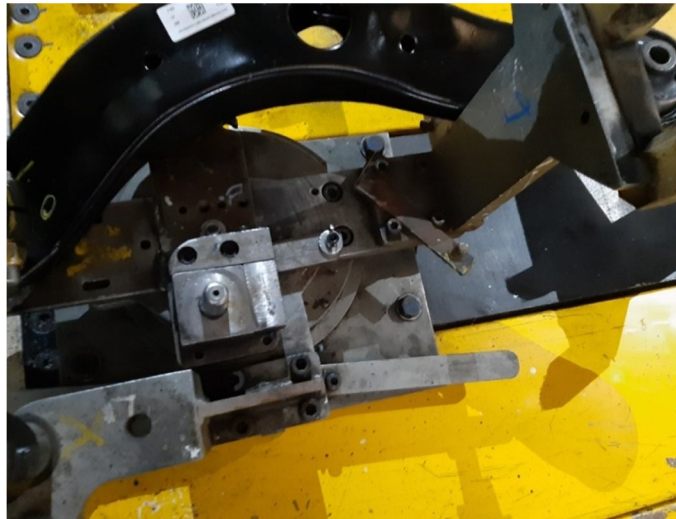


Figure 2: Existing Fixture Setup

Points Noted

- 1) Assembly time required at this particular station is approximately 14.092 seconds.
- 2) Minor stoppage time is on average 25.04 seconds.
- 3) Target of assemblies in a shift is 390 parts, but currently 310 parts are produced per shift.
- 4) Each working shift is of 8 hours in a day.

A. Analysis of the Existing System

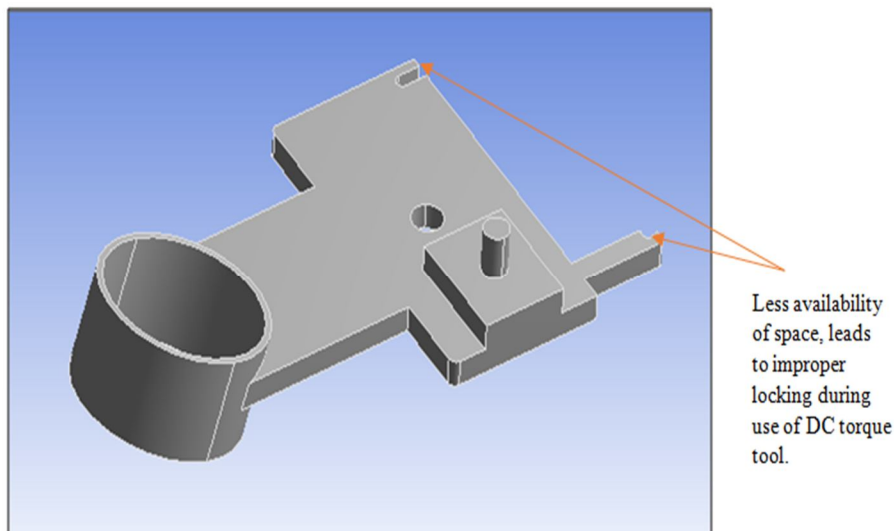


Figure 2.1.a: Existing Fixture Plate

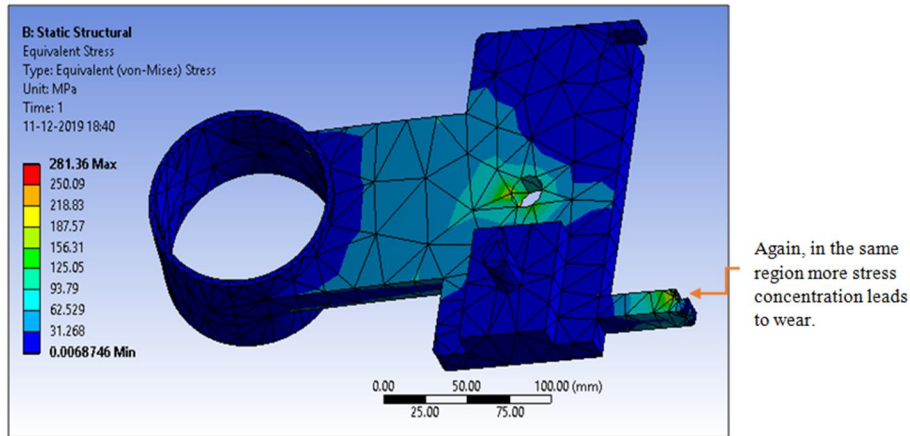


Figure 2.1.b: Analysis of fixture plate.

In the existing fixture plate space is very limited in the region of fastening, thus it becomes a crucial task during tightening. The above analysis shows that the locking may hamper with use of DC torque tool and also stress concentration is more in the same region which leads to wear of plate.

III. NEWLY DESIGN AND MODIFIED SYSTEM

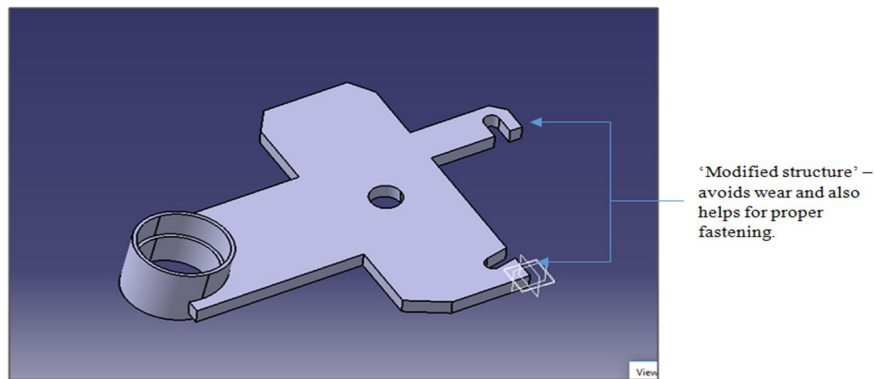


Figure 3.1: Modified Fixture Plate

Above figure 3.1 shows a modified structure of fixture plate. The newly designed plate overcomes the limitations that occurred in earlier plate. This design helps to appropriate fastening required during loading/unloading of component. Again in addition to the said modification, we use wing bolt instead of previously used allen bolt.

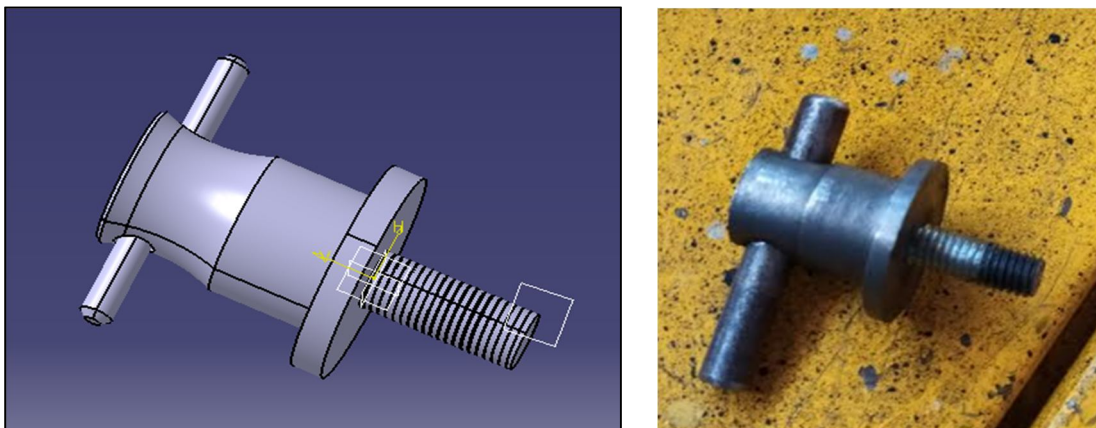


Figure 3.2: Wing Bolt

Here we replace allen bolt with wing bolt; just due to its several benefits over allen bolt. As in case of allen bolt we require particular key for its tightening and loosening. In case of wing bolt we have an arrangement like hand wheel which can easily operate manually by applying torque.

Thus the design modification in fixture plate and use of wing bolt all together eliminates the minor stoppages and gives a greater operator safety too.

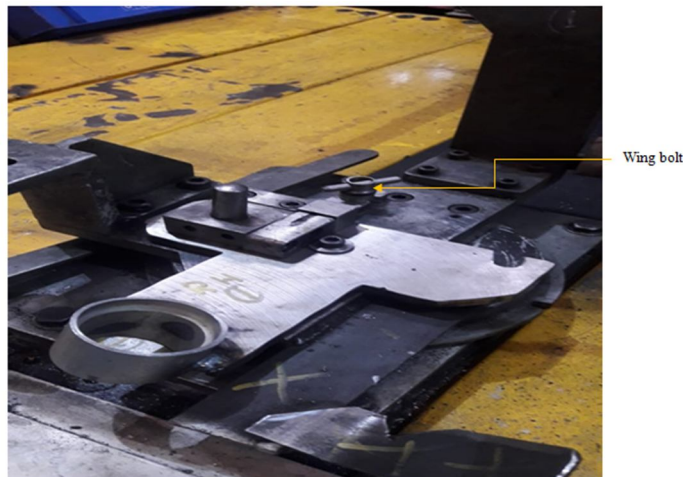


Figure 3.3: Actual Setup (After Modification)

Minor stoppages are actually different from normal breakdowns; they are occurring when the equipment either shuts down or idles due to a temporary problem. Just one minor stoppage can wipe out the advantages of automation. The micro method involves looking at the components and parts where minor stoppages have occurred and noting how they occur.

Thus, a zero minor stoppage is an essential goal in our workplace. In Earlier fixture plate we have space limitation that causes improper locking mostly with use of torque tool. But current modification avoids it completely resulting in zero stoppages.

IV. RESULT AND DISSCUSION

A. Minor Stoppages

Minor stoppages are recorded for old and newly implemented setup for one complete hour, and the same plotted graphically & discussed accordingly.



Chart 3.1 Minor stoppages for old and new system.

Discussion: With modified setup, it has been observed that, almost zero minor stoppage obtained.

B. Comparison of Time Required for Assembly of Steering Knuckle and Stub axle.

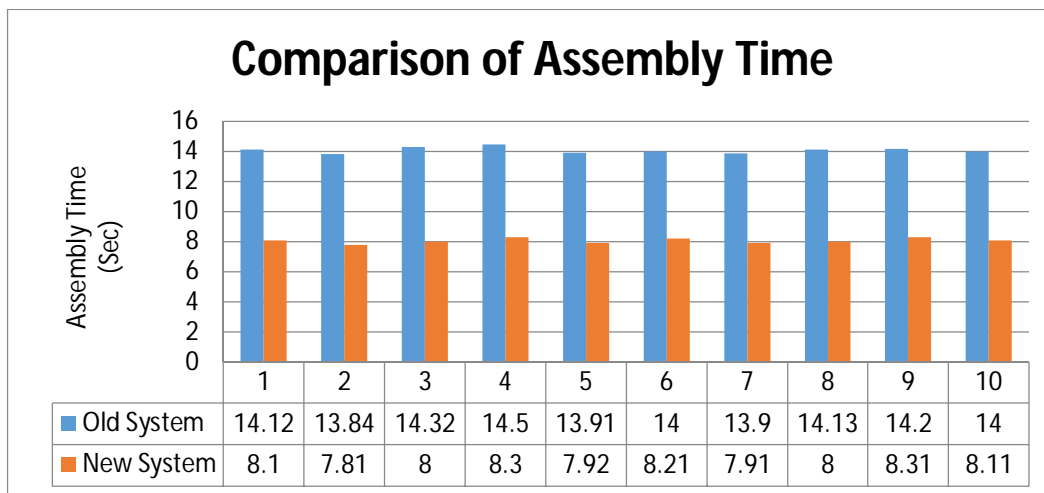


Chart 3.2 Comparison of time required for assembly.

Discussion: The above data shows the comparison of actual assembly time between old and newly implemented system. It clearly shows that with newly implemented system we have a considerable saving of time.

Time required per assembly is reduced approximately by 6.025 seconds.

Thereby it achieves the set target of assemblies per shift and noted that with modified system 410 numbers of part can assemble in a particular shift. It ultimately means, we have increase in productivity with greater operator safety.

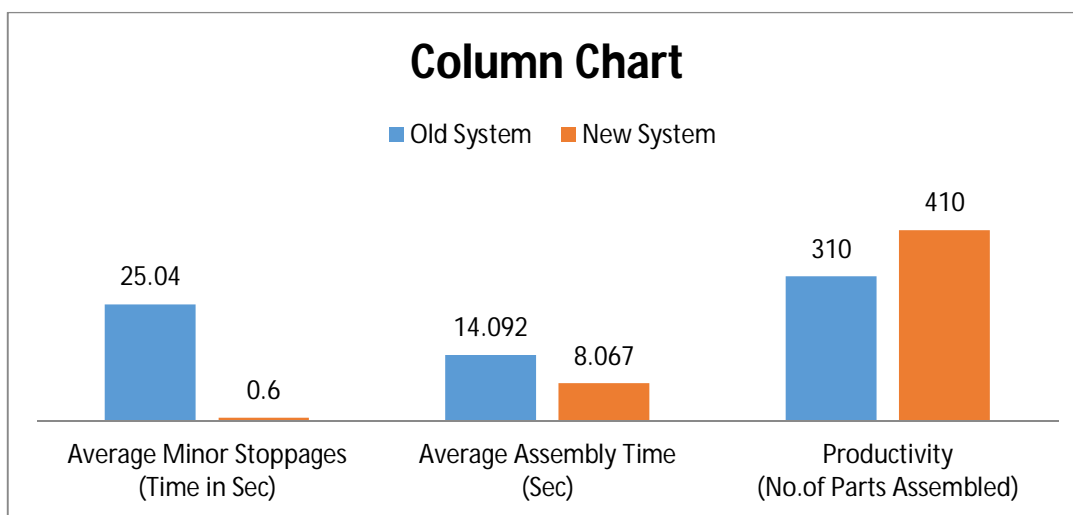


Chart 3.3 Column Chart - Old System vs. New System

Above column chart shows the result of newly designed system over earlier one, where minor stoppages are eliminated to zero and assembly time is also reduced resulting in increase in productivity.

V. CONCLUSION

This paper addresses the fixture design, modification issue. In this paper, for the sake of improvement in productivity certain desirable design modifications are done in existing system. For the same initially a detailed study, analyses of existing system was done and accordingly by following principle of fixture designs a new/better system designed and then implemented. After its successful implantation and testing, recorded results clearly shows there is an elimination of minor stoppages, reduction in time required for assembly of steering knuckle and stub axle, and therefore achieve increase in productivity.



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