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TIME STUDY ANALYSIS OF LOADING AND UNLOADING OF COMPONENT FROM A CNC FIXTURE

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Abstract— **Industrial Engineering Terminology defines time study as "a work measurement technique consisting of careful time measurement of the task with a time measuring instrument, adjusted for any observed variance from normal effort or pace and to allow adequate time for such items as foreign elements, unavoidable or machine delays, rest to overcome fatigue, and personal needs." In machining fixtures, minimizing work piece deformation due to clamping and cutting forces is essential to maintain the machining accuracy. Fixture is required in various industries according to their application. The fixture set up for component is done manually. For that more cycle time required for loading and unloading the material. So, there is need to develop system which can help in improving productivity and time. Fixtures reduce operation time and increases productivity and high quality of operation is possible. The fixture designing and manufacturing is a complex process that demands the knowledge of different areas, such as geometry, tolerances, dimensions, procedures and manufacturing processes.**

Index terms- **Fixture design, Spring sheet & Time study.**

I. INTRODUCTION

Time study is a direct and continuous observation of a task, using a time keeping device e.g., decimal minute stopwatch, computer-assisted electronic stopwatch, and videotape camera to record the time taken to accomplish a task. The success of any mass production depends upon the interchangeability to facilitate easy assembly and reduction of unit cost. Mass production methods demand a fast and easy method of positioning work for accurate operations on it. Jigs and fixtures are production tools used to accurately manufacture duplicate and interchangeable parts. Jigs and fixtures are specially designed so that large numbers of components can be machined or assembled identically, and to ensure interchangeability of components. Makwana and Gosavmi have found that there are different steps and approaches are available for designing the fixture. Among those geometry method (3-2-1 principle) and it is very useful for the complex fixture design though it is the basic principle of the fixture design. The application of science to business problems, and the use of time-study methods in standard setting and the planning of work, was pioneered by Frederick Winslow Taylor.

A. Time study:

A time and motion study (or time-motion study) is a business efficiency technique combining the Time Study work of Frederick Winslow Taylor with the Motion Study work of Frank and Lillian Gilbreth. Time study is a tried and tested method of work measurement for setting basic times and hence standard times for carrying out specified work. Its roots are back to the period between the two World Wars. The aim of time study is to establish a time for a qualified worker to perform specified work under stated conditions and at a defined rate of working. Time study is a direct and continuous observation of a task, using a timekeeping device (e.g., decimal minute stopwatch, computer-assisted electronic stopwatch, and videotape camera) to record the time taken to accomplish a task and it is often used when:

- there are repetitive work cycles of short to long duration
- wide variety of dissimilar work is performed, or
- Process control elements constitute a part of the cycle.

The Industrial Engineering Terminology Standard defines time study as "a work measurement technique consisting of careful time measurement of the task with a time measuring instrument, adjusted for any observed variance from normal effort or pace and to allow adequate time for such items as foreign elements, unavoidable or machine delays, rest to overcome fatigue, and personal needs.

B. Fixture:

It is a work holding device that holds supports and locates the work piece for a specific operation but does not guide the cutting tool. It provides only a reference surface or a device. Fixtures provide a means to reference and align the cutting tool to the work piece but they do not guide. Each fixture is unique as it is built to fit a particular part or shape. The main purpose of a fixture is to locate and in some cases hold a work piece during either a machining operation or some other industrial process. Fixtures that have the added function of guiding the tool during manufacturing are called jigs. Example: chucks.

C. Spring sheet component:

Spring sheet is a component made up of mild steel alloyed with Carbon, Silicon, Manganese, Potassium, Copper, Sulphur and Aluminum of different proportions based on the requirement. Spring sheet is used in medium and heavy duty vehicle axles. Spring Sheets are used by companies like Automotive axle Limited, Wipro industries, KTMS, etc.

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Fig.1.3 spring sheet component

Spring sheets are forged to required dimension which has taper section at one half. Then the component undergoes specific machining operation. The spring sheet must be clamped on a fixture having an angled plate or block to account the taper of the component.

II. TYPE OF MACHINING OPERATIONS CARRIED OUT ON THE SPRING SHEET IN THE GRS ENGINEERING PRIVATED LIMITED

- Top surface facing operation
- Drilling operation
- Finishing operation

A. Top surface facing operation:

Fig.2.1.Top surface facing operation

In this operation first spring sheet has to be held in U shape block fixture which has angle plate to compensate the taper of the component. Spring sheet is seated on a center block and then it is tightened with bolts and keys. Once spring sheet is clamped on a fixture, top facing operation is to be carried out. After achieving of the required dimension, spring sheet undergoes next operation.

B. Drilling operation:

Drilling operation is 2nd operation, carried in the same machine

Set up with tool change to drill bit in the pallet of the CNC. A

17.5mm hole will be drilled with the help of drill bit. After drilling, reaming operation is carried to size the drilled hole.

Fig.2.2 Drilled components

Fig.2.2. shows the drilled components and unmachined components. Drilling carried on at top face of spring sheet which already machined in first operation. After completion of drilling operation, next operation is finishing operation that is final operation with help of burr removal tools.

C. Finishing Operation:

Fig.2.3 Burr removal process and packed components

The machined component will have burrs and sharp edges which are necessary to remove else which may cause harm to workers while handling or may cause problem during assembly with other parts. To remove burrs and sharp edges manual deburring operation is done with the help of burr removal hand tool. Then the component is applied with the rust preventive oil. The component is sent to final inspection where component number is printed and dipped in rust preventing oil-axonal 33cd or Caster oil and hydraulic oil. Then the components are ensured for rusts, dents, cracks, burrs etc. and packed in a VCI covers. Packed components are shipped to the predetermined destinations.

III. TIME STUDY

Time study is a work measurement technique for recording the times and rates of working for the elements of a specified job carried out under specified conditions, and for analysing the data so as to obtain the time necessary for carrying out the job at a defined level of performance. In order to make time studies certain equipment is essential. Basic time study equipment consists of:

- a stopwatch;
- a study board;
- pencils;

- Time study forms.

This equipment the study man will need with him whenever he makes a time study. In addition there should be in the study office:

- slide rules;
- a reliable clock, with seconds hand;
- Measuring instruments such as tape measure, steel rule, micro meter, spring balance, and tachometer (revolution counter). Other measuring instruments may be useful, depending on the type of work being studied.

It is an advantage to have in the study office also:

- an adding machine, or simple form of calculating machine

The work/process to be studied is selected. The making of a time study usually consists of the following eight steps:

- Obtaining and recording all the information available about the job, the operator and the surrounding conditions, which is likely to affect the carrying out of the work.
- Recording a complete description of the method, breaking down the operation into "elements"
- Examining the detailed breakdown to ensure that the most effective method and motions are being used.
- Measuring with a timing device (usually a stopwatch) and recording the time taken by the operator to perform each "element" of the operation.
- At the same time assessing the effective speed of the working of the operative in relation to the observer's concept of the rate corresponding to standard rating.
- Extending the observed times to "basic times"
- Determining the allowances to be made over and above the basic time for the operation.
- Determining the "standard time" for the operation.

A. CNC Fixture – U block:

Fig.3.1.U-block CNC fixture

The U-block CNC fixture is used to hold the spring sheet component during machining operation on a CNC. The fixture has angled plate which accounts the taper of the component. When the Spring Sheet is clamped on the fixture the top surface of the component will be parallel to the base plate of the fixture i.e. parallel to X-axis in spite of taper of the component. So butting should be made properly to get a straight surface. To keep the Spring Sheet firmly on the Fixture locating and locking pins are used. The pins are sufficiently tightened so the component will not vibrate during machining operation due to cutting forces acting on the component. So all these process takes more time in loading and unloading of a component which increases lead time. Time study is conducted to find a standard time to load and unload a component on a CNC machine with the help of a stop watch and Time study forms.

B. CNC Fixture – 3 Jaw chuck:

Fig.3.2.3 Jaw Chuck CNC fixture

Fig.3.2 shows the 3 jaw chuck fixture which was designed to reduce the loading and unloading time of component. It has a base plate with 3 slots to fit the 3 jaws of the fixture. These 3 jaws hold the component firmly at the center. The base plate is fitted to CNC machine with the help of nut and bolts. It has center space provided for center block to support the spring sheet component. The inner surface of the component rests on the fixture. To avoid the wear, wear pad will be provided between fixture and the component. The component has taper at one end. The inner surface of the component is placed on the center support block. The support block has taper at one end to compensate the taper of the spring sheet component. So when the component is placed on the center support block the surface of the component will be flat and parallel to horizontal axis. The support block has chamfer at the ends to provide grip to the component to sit firmly on the support block. Once component is placed the three jaws are moved with the help of a chuck key. The three jaws moves simultaneously and holds the component firmly in the center. The loading and unloading time of component required for this fixture is less. Time study is conducted to find the standard time of loading and unloading with the help of stop watch and time study forms.

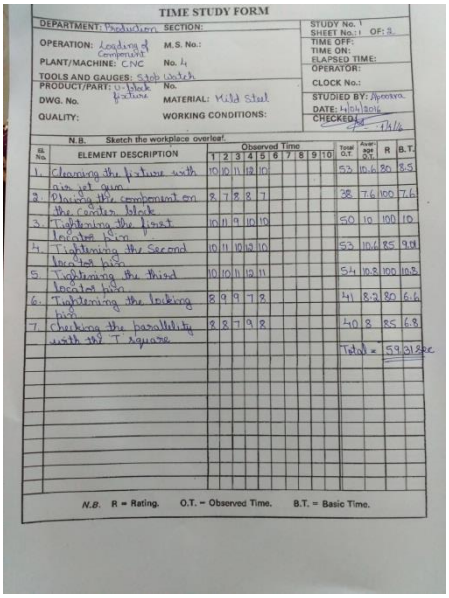
C. Comparison between U- block fixture and 3 jaw chuck fixture:

1) U-Block Fixture:

Time study of loading and unloading of component from the U block fixture is done with the help of Stop watch and time study form. The basic time and standard time are calculated using the formulas. According to the time study it takes 59.3 sec to load and 57sec to unload the component from the fixture. The allowance given is 12% which is used to calculate the standard time.

Standard time = Basic time + allowance
Standard time = (57+59.3) + (0.12*116.3) = 130.26 sec

The standard time required to load and unload the component from the U-block fixture is 2 min 10sec.



TIME STUDY FORM

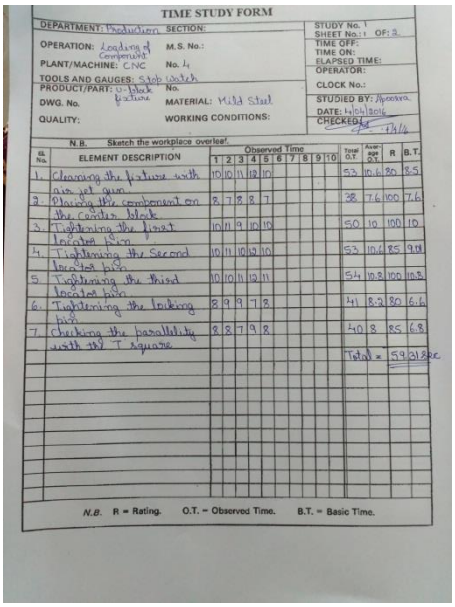
DEPARTMENT: Production SECTION:
OPERATION: Loading of Components M.S. No.:
PLANT/MACHINE: CNC No. 4
TOOLS AND GAUGES: Stop watch
PRODUCT/PART: U-block fixture No.
DWG. No. MATERIAL: Mild Steel
QUALITY: WORKING CONDITIONS:
STUDY No. 1 SHEET No.: 1 OF: 2
TIME OFF: TIME ON: ELAPSED TIME:
OPERATOR:
CLOCK No.:
STUDIED BY: Apoorva
DATE: 1/04/2016
CHECKED:

N.B. Sketch the workplace overleaf.

Sl. No.	ELEMENT DESCRIPTION	Observed Time 1	2	3	4	5	6	7	8	9	10	Total O.T.	Average O.T.	R	B.T.
1.	Cleaning the fixture with air jet gun	10	10	11	12	10						53	10.6	80	8.5
2.	Placing the component on the center block	8	7	8	8	7						38	7.6	100	7.6
3.	Tightening the first located pin	10	11	9	10	10						50	10	100	10
4.	Tightening the Second located pin	10	11	10	12	10						53	10.6	85	9.01
5.	Tightening the third located pin	10	10	11	12	11						54	10.8	100	10.8
6.	Tightening the locking pin	8	9	9	7	8						41	8.2	80	6.6
7.	Checking the parallelity with the T square	8	8	7	9	8						40	8	85	6.8
												Total = 59.2 sec			

N.B. R = Rating. O.T. = Observed Time. B.T. = Basic Time.

Fig.3.3.1a.Time study form–loading to U-block fixture



TIME STUDY FORM

DEPARTMENT: Production SECTION:
OPERATION: Loading of Components M.S. No.:
PLANT/MACHINE: CNC No. 4
TOOLS AND GAUGES: Stop watch
PRODUCT/PART: U-block fixture No.
DWG. No. MATERIAL: Mild Steel
QUALITY: WORKING CONDITIONS:
STUDY No. 1 SHEET No.: 1 OF: 2
TIME OFF: TIME ON: ELAPSED TIME:
OPERATOR:
CLOCK No.:
STUDIED BY: Apoorva
DATE: 1/04/2016
CHECKED:

N.B. Sketch the workplace overleaf.

Sl. No.	ELEMENT DESCRIPTION	Observed Time 1	2	3	4	5	6	7	8	9	10	Total O.T.	Average O.T.	R	B.T.
1.	Cleaning the fixture with air jet gun	10	10	11	12	10						53	10.6	80	8.5
2.	Placing the component on the center block	8	7	8	8	7						38	7.6	100	7.6
3.	Tightening the first located pin	10	11	9	10	10						50	10	100	10
4.	Tightening the Second located pin	10	11	10	12	10						53	10.6	85	9.01
5.	Tightening the third located pin	10	10	11	12	11						54	10.8	100	10.8
6.	Tightening the locking pin	8	9	9	7	8						41	8.2	80	6.6
7.	Checking the parallelity with the T square	8	8	7	9	8						40	8	85	6.8
												Total = 59.2 sec			

N.B. R = Rating. O.T. = Observed Time. B.T. = Basic Time.

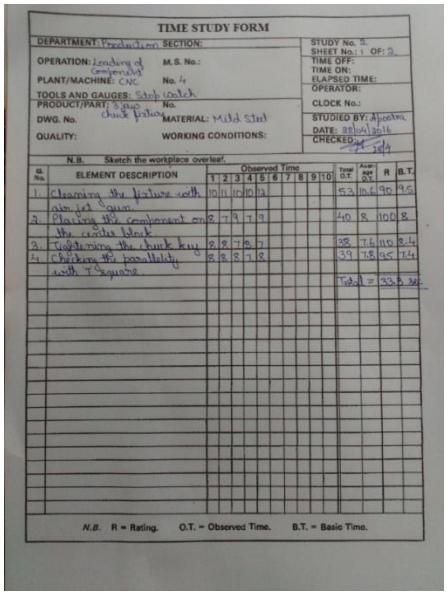
Fig.3.3.1b.Time study form–unloading to U-block fixture

2) Three Jaw chuck fixture:

Time study of loading and unloading of component from the 3 jaw chuck fixture is done with the help of Stop watch and time study form. The basic time and standard time are calculated using the formulas. According to the time study it takes 33.3 sec to load and 25.2sec to unload the component from the fixture. The allowance given is 12% which is used to calculate the standard time.

Standard time = Basic time + allowance
Standard time = (33.3+25.2) + (0.12*58.5) = 65.52 sec

The standard time required to load and unload the component from the three chuck is 1 min 6sec.



TIME STUDY FORM

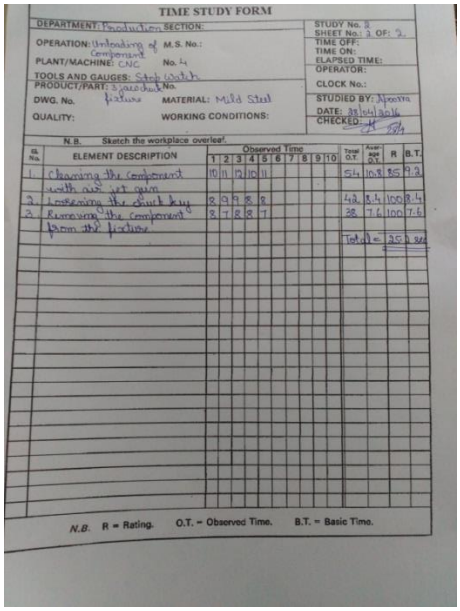
DEPARTMENT: Production SECTION:
OPERATION: Loading of Components M.S. No.:
PLANT/MACHINE: CNC No. 4
TOOLS AND GAUGES: Stop watch
PRODUCT/PART: 3 jaw chuck fixture No.
DWG. No. MATERIAL: Mild Steel
QUALITY: WORKING CONDITIONS:
STUDY No. 2 SHEET No.: 1 OF: 2
TIME OFF: TIME ON: ELAPSED TIME:
OPERATOR:
CLOCK No.:
STUDIED BY: Apoorva
DATE: 28/04/2016
CHECKED:

N.B. Sketch the workplace overleaf.

Sl. No.	ELEMENT DESCRIPTION	Observed Time 1	2	3	4	5	6	7	8	9	10	Total O.T.	Average O.T.	R	B.T.
1.	Cleaning the fixture with air jet gun	10	11	10	10	11						52	10.6	90	9.5
2.	Placing the component on the center block	8	7	9	7	9						40	8	100	8
3.	Tightening the chuck key	8	8	7	8	7						38	7.6	110	8.4
4.	Checking the parallelity with T square	8	8	8	7	8						39	7.8	95	7.4
												Total = 33.3 sec			

N.B. R = Rating. O.T. = Observed Time. B.T. = Basic Time.

Fig.3.3.2a.Time study form–loading to 3 jaw chuck fixture



TIME STUDY FORM

DEPARTMENT: Production SECTION:
OPERATION: Unloading of Components M.S. No.:
PLANT/MACHINE: CNC No. 4
TOOLS AND GAUGES: Stop watch
PRODUCT/PART: 3 jaw chuck fixture No.
DWG. No. MATERIAL: Mild Steel
QUALITY: WORKING CONDITIONS:
STUDY No. 2 SHEET No.: 2 OF: 2
TIME OFF: TIME ON: ELAPSED TIME:
OPERATOR:
CLOCK No.:
STUDIED BY: Apoorva
DATE: 28/04/2016
CHECKED:

N.B. Sketch the workplace overleaf.

Sl. No.	ELEMENT DESCRIPTION	Observed Time 1	2	3	4	5	6	7	8	9	10	Total O.T.	Average O.T.	R	B.T.
1.	Cleaning the component with air jet gun	10	11	12	10	11						54	10.8	85	9.2
2.	Loosening the chuck key	8	9	9	8	8						42	8.4	100	8.4
3.	Removing the component from the fixture	8	7	8	8	7						38	7.6	100	7.6
												Total = 25.2 sec			

N.B. R = Rating. O.T. = Observed Time. B.T. = Basic Time.

Fig.3.3.2b.Time study form–unloading to 3 jaw chuck fixture

3) Graphical Representation:

The bar chart shows the graphical representation of the loading time, unloading time and allowance of 12% which all together gives the standard time of loading and unloading of component from the both U-block and 3 jaw chuck fixture. Time is represented in the scale of seconds.

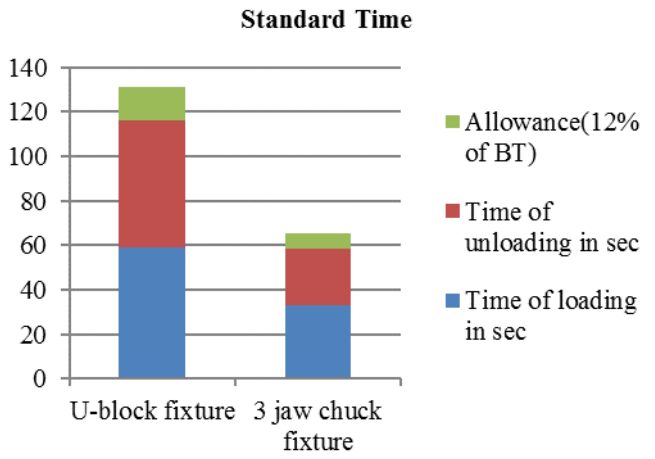


Fig.3.3.3. Graphical Representation

IV. CONCLUSION

Fixtures are the essentials part of any manufacturing setup, the purpose of fixture is to hold the work piece in such way that these should facilitate machining. Fixtures have a direct impact upon product manufacturing quality, productivity and cost. Fixture design needs to be tested and evaluated in real manufacturing environments and integrated with other design activities, which often are related with production resources, equipment, cost and machining processes, etc. The design of the fixture should be simple, so the loading and unloading of component is very easy and reduces time of loading unloading of component which in turn reduces the production lead time. As the production rate increases profit in terms of man, machine, material, and money. The worker can easily load and unload the component on a CNC. Time study helps to find out the standard time and to choose a best fixture for a component. The time study in this research has proved that 3 jaw chuck fixture is simple in design and easy to load and unload. Time required for loading and unloading a component in 3 jaw chuck fixture is 50% less than the U-block fixture. It is a best design. The fixture has to be designed with minimum number of parts. Hence these results should indicate that the design is well within the safe limits of operation.

V. FUTURE SCOPE

By the successful trail run, 3 jaw chuck fixture is more comfortable than U-block fixture. So this fixture can be used in manufacturing companies because of its simple design and less cost. Block is attached with the help of locating dowel pins. Wear pad is provided between fixture and the component to avoid wear and tear of the fixture and to avoid any damage to the component. The component is placed on the center support block firmly. With this fixture design 2 jaw fixture design can be tried in the future to have a simple design than the 3 jaw chuck.

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