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DESIGN AND DEVELOPMENT FIXTURES TO SPEED UP ASSEMBLY AND IMPROVE QUALITY

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Abstract – Fixtures are commonly used tools for assembly to hold workpieces proper position. The fixture's positioning accuracy is also an important factor impacting overall accuracy. There are two assembly fixtures one is for rod end bearing assembly and the other is for motorization block assembly fixture. In the assembly of rod end bearing parts, older fixtures had issues with ball alignment in more than 15% of the parts, and most of the parts showed flash, productivity, and low-quality issues. In the motorization block assembly old process fixture was not used and the assembly was manually performed. Manual assembly takes time, increases the chance of the wrong assembly, and damages bearings during hammering. After developing a new fixture, rod end bearing assembly problems with ball alignment, and flash were all resolved, and the product's quality and productivity both increased. In the motorization block assembly, problems with bearing damage during hammering, and wrong assembly were all resolved after developing a new fixture, and increased product quality and productivity both improved. In rod end bearing assembly 500 Qty, the old fixture produces them in 4.16 hours whereas the new fixture does it in 3.19 hours, and the motorization block assembly fixture resulted in enhanced quality, decreased cycle time, higher productivity, and zero bearing damage during hammering. In moto assembly 50 Qty was produced in total during 3.33 hours without fixtures and 1.25 hours of new fixtures.

Keywords – Fixture design, Computer-aided fixture design, Assembly fixture, Accuracy, productivity, Cost, Production time, Production rate.

INTRODUCTION

Fixture - A fixture is a tool for positioning and holding the workpiece in the manufacturing sector. The main function of a fixture is to provide a stable mounting place for a workpiece, enabling support during use and improved accuracy, precision, dependability, and interchangeability of the finished components. By providing a fast setup and simplifying the transfer from one segment to the next, it also cuts down on working time. When a process is simplified, it typically makes it possible for workers without special training to complete it, Moreover, fixtures increase worker safety by requiring lesser effort and energy to maintain a piece stationary. The most beneficial use of a fixture from an economical perspective is to reduce labour costs. Without a fixture, a process or operation may take two or more workers to operate by holding the workpiece, a fixture can replace one of these workers.

Types of Fixtures – Milling fixtures, turning fixtures, tapping fixtures, boring fixtures, welding fixtures, assembly fixtures, etc.

Assembly fixtures - When assembling various components, these fixtures keep them all together in the correct relative location. Assembly fixtures are instruments that allow the assembly of two or more components more quickly. A good assembly fixture is required for any mass production processes to be improved. Before assembling, fixtures need to be organized and set according to the specific operational instruments that will be utilized. The correct fixtures, once installed, speed up and improve the maximum production of your company. For example, two or more pieces can be fastened together in the correct positions with a bolt. As parts are put together during assembly, assembly fixtures hold them precisely aligned. These fixture devices are commonly fixed manually or automatically used around objects.

3-2-1 Principle – The 3-2-1 strategy is a work-holding technique.
Locating a part to be assembled is a three-step process.

1. Supporting
2. Positioning
3. Clamping

The workpiece's travel along three axes XX, YY, and ZZ is limited by the location principle (3-2-1) also known as the six-point location principle. Six locating points - three in the base plate, two in the vertical plane, and one pin in a plane that is perpendicular to the first two planes.

1. X-axis positive & negative direction movement
2. Y-Axis positive & negative direction movement
3. Z-Axis positive & negative direction movement
4. X-axis clockwise and anti-clockwise direction rotation
5. Y-axis clockwise and anti-clockwise direction rotation
6. Z-axis clockwise and anti-clockwise direction rotation

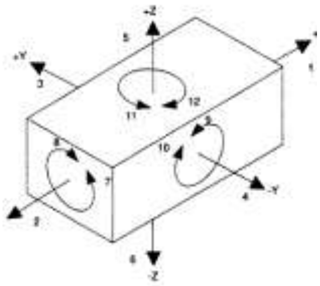

Figure 1 – Degree of freedom

When mounting an item in a fixture for assembly, we want to complete two things.

1. Exact the part's location at the specified coordinates.
2. Limit each of the six degrees of freedom to prevent the part from moving.

PROBLEM IDENTIFICATION

Problems Occurring in Existing Fixtures are.

Rod end-bearing assembly fixture

1. Fixtures that don't hold them precisely, most of the parts observed after injection molding was flash.
2. More than 15% of the parts observed ball alignment issues because of the housing and ball not being properly aligned.

Motorization block assembly fixture

1. Motorization block Assemble using pins, inserting pins into the hole with a hammer, hammering directly impacts a bearing and causes bearing damage.
2. Wrong assembly.
3. Quality issues observed every time.
4. Manual assembly is more time-consuming.

OBJECTIVES

Rod end-bearing assembly fixture

1. To reduce flash
2. To solve ball alignment issues
3. To increase productivity

Motorization block assembly fixture

1. To reduce bearing damage during the hammering process
2. To reduce time in the assembly process
3. To improve the product's quality
4. To increase productivity

METHODOLOGY

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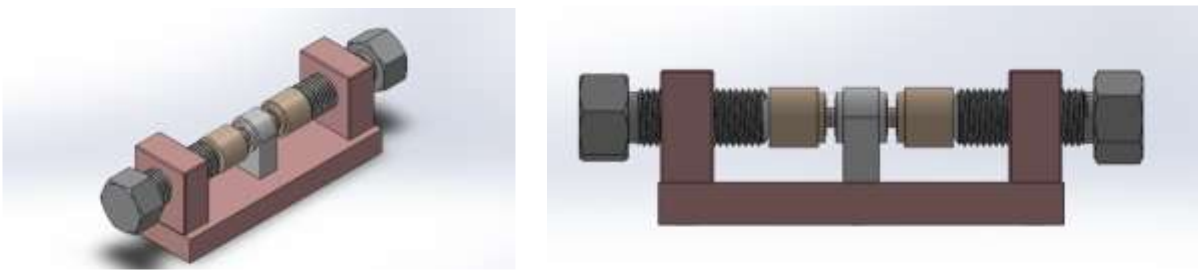
The entire research technique and operating processes shown below are required to achieve the project's objectives.

CAD Model
↓
Material Selection
↓
Material Testing
↓
Process flow chart
↓
Manufacturing
↓
Quality Inspection
↓
Testing

FIXTURE DESIGN

The design process method is one of the procedures required for product development. The product was also considered in the design process, including the holding position, weight distribution, material selection, and additional design analysis and information. Designing is done using the software SolidWorks.

Rod end bearing assembly fixture – The fixture is made up of eight separate pieces, and several sections serve different functions. In designing fixtures for long-term use, ISO 2768-1 Specified tolerances are provided for this fixture's accurate fitting of assembly parts. This new fixture produces two-rod end bearing assemblies at a time, while the previous fixture only one-rod end bearing assembly produces at a time.



(a) (b)

Figure 2 – Rod end bearing assembly fixture

Motorization block assembly fixture – The fixture is made up of three separate pieces, and several sections serve different functions. Also in this fixture, ISO 2768-1 Specified tolerances are provided for this fixture's accurate fitting of assembly parts. All factors, such as ease of manufacture and tool availability, are considered while designing fixtures. An untrained person can also use a poka-yoke or mistake-proof method easily. Motorization block assembly with pins, hammering pins into the hole and using assembly with fixture hammering directly without damaging a bearing impact pass-through shaft to the fixture.

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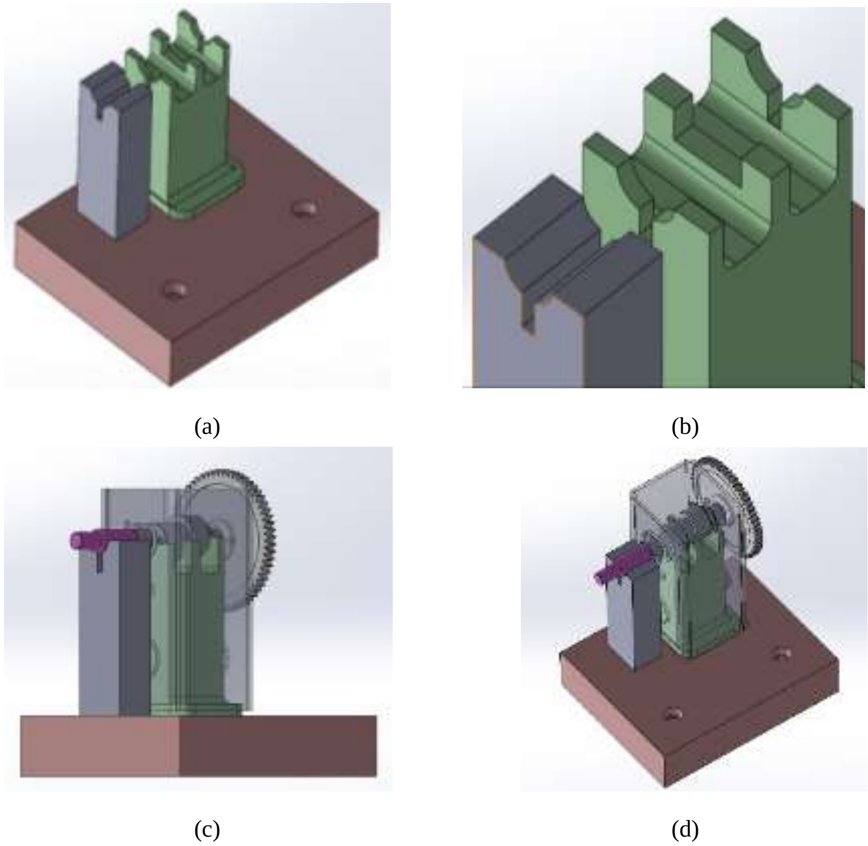

Figure 3 – Motorization block assembly fixture

MATERIAL SELECTION & MATERIAL TESTING

SS 304 & SS 316 chemical and mechanical properties are good for fixture design. Rust and corrosion-proof are easily available in the market.

The main benefit of SS 304 and SS 316 stainless steel is its durability. In comparison to SS 304 stainless steels, which have 18.25% chromium and 8.03% nickel, SS 316 stainless steels have 16.71% chromium, 10.02% nickel, and 2.03% molybdenum. The addition of molybdenum has given SS 316 stainless steel improved corrosion-resistant properties.

Material - SS 304								
Chemical Composition (%)								
C	Mn	Si	S	P	Cr	Ni	N	Mo
0.052	0.99	0.35	0.002	0.041	18.25	8.03	0.053	-
Mechanical Test Results								
Tensile strength			684			Mpa		
Yield strength			310			Mpa		
Elongation			64			%		

Table 1 – Material - SS 304 Chemical Composition & Mechanical Test Results

Material - SS 316								
Chemical Composition (%)								
C	Mn	Si	S	P	Cr	Ni	N	Mo
0.022	1.40	0.35	0.002	0.032	16.71	10.02	0.036	2.03
Mechanical Test Results								
Tensile strength			618			Mpa		
Yield strength			329			Mpa		
Elongation			55			%		

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Table 2 – Material - SS 316 Chemical Composition & Mechanical Test Results

Material Testing by PMI (Positive Material Identification) machine – to check easily Material Chemical Composition. Check the hardness of the material using hardness testing equipment.

Material - SS 304

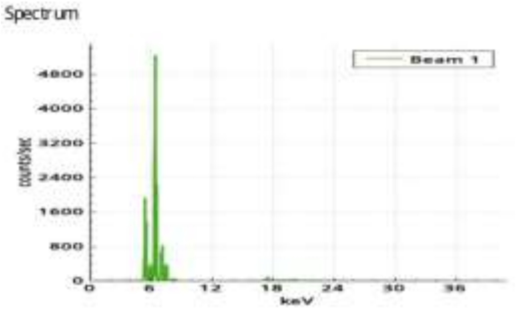
Chemistry

SUS304N2 1_4301 1_4310

SUS304N2

0.1

El	%	+/-3σ
V	0.096	0.033
Cr	17.70	0.21
Mn	1.06	0.13
Fe	71.93	0.30
Co	0.16	0.14
Ni	8.30	0.20
Cu	0.442	0.055
Zn	0.055	0.016
Nb	0.013	0.004
Mo	0.241	0.011



(a) (b)

Figure 4 – SS 304 material test report

Material - SS 316

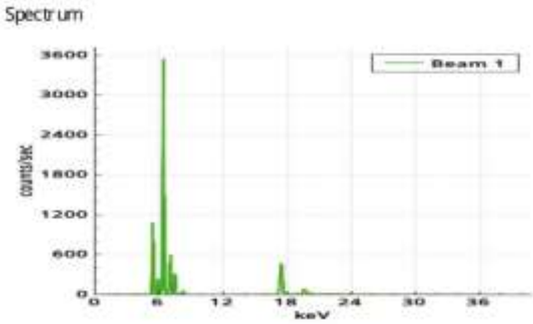
Chemistry

316 SUS316 SUS316F

316

0.7

El	%	+/-3σ
V	0.094	0.041
Cr	15.87	0.24
Mn	1.20	0.15
Fe	69.77	0.37
Co	0.40	0.17
Ni	10.04	0.27
Cu	0.469	0.070
Zn	0.084	0.023
Nb	0.017	0.005
Mo	2.048	0.041



(a) (b)

Figure 5 – SS 316 material test report

MANUFACTURING

Rod end bearing assembly fixture is manufactured in VMC and CNC machines and moto assembly fixture is manufactured in VMC machines only. The size of the raw materials is listed below for both fixtures. Both stainless steel grades SS 304 and SS 316 are easily machined.

Rod end bearing assembly fixture			
Sr.no.	**Material**	**Raw Material Size**	**Weight (Kg)**
1.	SS AISI 316-BLK-SQR	65 X 65 X 60	2.049
2.	SS AISI 304-BGT-SQR-ANL	35 X 35 X 100	0.990
3.	SS AISI 304-BGT-RND	30 X 100	0.560
4.	SS AISI 304-HEX	38.1 X 230	2.337

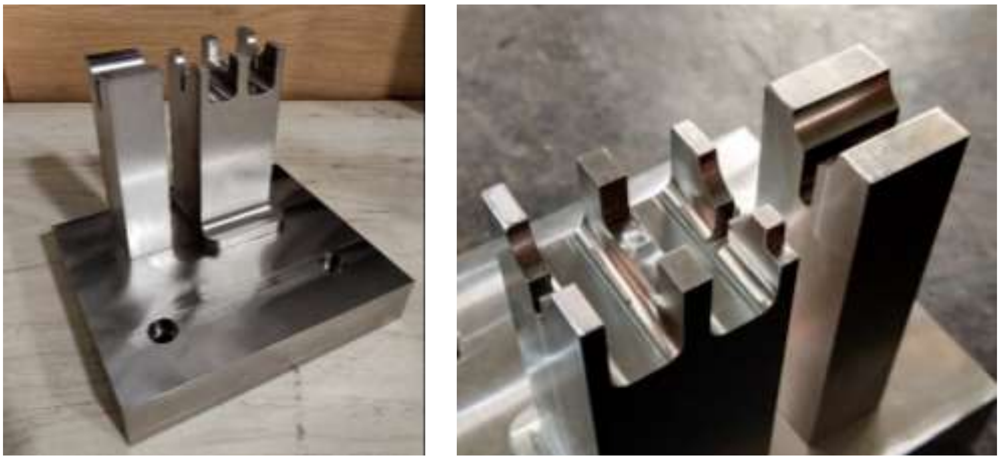
Table 3 – Rod end bearing assembly fixture row material size and weight

(a) (b)

Figure 6 – Manufactured rod end-bearing assembly fixture

Motorization block assembly fixture			
Sr.no.	**Material**	**Raw Material Size**	**Weight (Kg)**
1.	SS AISI 316-BLK-SQR	65 X 65 X 120	4.099
2.	SS AISI 304-BGT-SQR-ANL	35 X 35 X 120	1.188
3.	SS AISI 304	160 X 130 X 30	5

Table 4 – Motorization block assembly fixture row material size and weight



(a) (b)

Figure 7 – Manufactured motorization block assembly fixture

FINAL INSPECTION

A variety of quality instruments, such as a digital vernier caliper, digital micrometer, vernier height gauge, vernier depth gauge, lever dial gauge, radius gauge, etc. are used to inspect manufacturing fixtures after they have been manufactured. The final inspection report should verify that this fixture's dimensions are all within the tolerances specified in ISO 2768-1.

COMPARISON B/W OLD FIXTURE AND NEW FIXTURE

Rod end bearing assembly fixture

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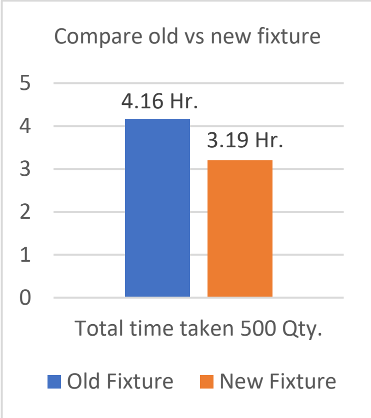
Existing Fixture for a rod end bearing assembly.

A shift has a total working time of 7 hours. 30 minutes, or 450 minutes (30 minutes utilized in lunch break). A total number of two shifts. A total number of finished parts in each shift = 500 Nos.

An old fixture per piece produces an average of 30 sec.
30 Sec X 50 Qty =1500 / 60 = 25 Min
500 Qty = 250 Min or 4.16 Hr.



4.16 Hr. X 26 shifts = 108.16 Hr.
26 shifts X 500 Qty = 13,000 Qty per month produced in one shift
Two shifts 26,000 Qty in 216.32 Hr. for complete

After implementation, a new fixture per piece produces an average of 23 sec.
23 Sec x 50 Qty = 1150 / 60 = 19.17 Min
500 Qty = 191.67 Min or 3.19 Hr.
3.19 Hr. X 26 shifts = 82.94 Hr.
26 shifts X 500 Qty = 13,000 Qty per month produced in one shift
Two shifts 26,000 Qty in 165.88 Hr. for complete
Total save time 50.44 Hr. in a month.
One shift labour charge of 15000 per month on an average
15,000/26 = 576.92 for one day
For one hour 76.92
76.92 X 108.16 Hr. = 8,320/- for one shift a month
76.92 X 216.32 Hr. = 16,640/- for two shifts a month

One shift labour charge of 15000 per month on an average
15,000/26 = 576.92 for one day
For one hour 76.92
76.92 X 82.94 Hr. = 6,380/- for one shift a month
76.92 X 165.88 Hr. = 12,760/- for two shifts a month

Total save labour cost in a month.
One shifts a month 1940/-
Two shifts a month 3880/-

(a) (b)

Figure 8 – Compare old vs new rod end bearing assembly fixture.

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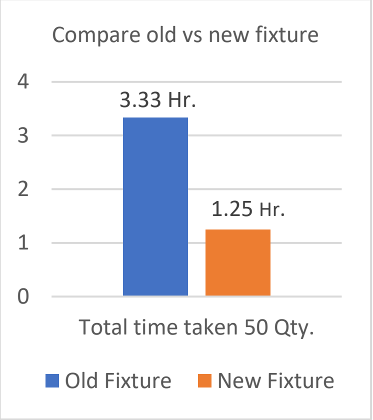
Motorization block assembly fixture

Old process without a fixture

1 Qty X 4 Min
50 Qty X 4 Min = 3.33 Hr.

New process with fixture

1 Qty x 1.5 Min
50 Qty X 1.5 Min = 1.25 Min



An old process without fixture one qty 4 min & using fixture per piece produces in 1.5 min. Total save time 2.5 min per piece. 50 pieces produce without a fixture 3.33 Hr. & With fixture 1.25 Hr.
One shift labour charge 15000 per month
15,000/26 = 576.92 for one day
For one hour 76.92

50 pieces produce by
76.92 X 1.25 Hr. = 96.15/-
76.92 X 3.33 Hr. = 256.15/-
Total saved labour costs 160/-

(A)	**Rod end bearing assembly fixture**	
1.	Old fixture one comes out at a time	New fixture two come out at a time
2.	M S material	S S material
3.	More wear	Less wear
4.	Flash or Burrs observe all time, Burrs removing time also increases.	Flash or Burrs observe in rare cases.
5.	En8 Material price – Rs.65/Kg	SS 304 Material price - Rs.205/Kg SS 316 Material price - Rs.345/Kg
(B)	**Motorization block assembly fixture**	
1.	Old assembly process fixture is not used	A new assembly process fixture is used
2.	Bearing damage during hammering	Bearing no damage during hammering
3.	When Bearing damage rework time increase as well as cost also increase	Less chances of bearing damage
4.	More time consumed in the assembly process	Less time consume in the assembly process
5.	En8 Material price – Rs.65/Kg	SS 304 Material price - Rs.205/Kg SS 316 Material price - Rs.345/Kg

Table 5 – Compression old vs new

CONCLUSIONS

The previous rod end bearing assembly fixture had problems with ball alignment in more than 15% of the parts, the maximum part observed flash, low productivity, and low-quality issues. The proper design of the new fixture results in improvements in quality, productivity, cycle time, ball alignment problem solved, and flash not observed. It is being increased from 400 units to 500 units per shift for the result. Moreover, the cycle time for the rod end bearing assembly has been decreased from 30 to 23 seconds, saving a total of 7 seconds for each assembly. For 500 Qty, the old fixture produces them in 4.16 hours whereas the new fixture does it in 3.19 hours.

The previous motorization block fixture wasn't used the assembly was performed manually. Manual assembly is time-consuming, increases the chances of the wrong assembly, and damages bearings during hammering. The new fixture's implementation resulted in enhanced quality, decreased cycle time, higher productivity, and zero bearing damage during hammering. Furthermore, the cycle time for the motorization block assembly has been reduced from 4 minutes to 1.5 minutes, saving a total of 2.5 minutes for each assembly. 50 Qty was produced in total during 3.33 hours without fixtures and 1.25 hours of new fixtures.

The quality of the finished product is increased overall, the assembly fixture is more flexible, it takes less time to assemble, and it produces low costs.

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