Design and Fabrication of Combination Fixture for Reducing Production Time in Pump Manufacturing

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***Abstract*—In most of pump manufacturing industries, three fixtures are used for performing machining operations like milling, drilling and tapping on the components such as rear cover, front cover, suction bracket and casing. They lead to increase loading time, setting time, machining time and unloading time. To reduce the production time significantly, the three fixtures are replaced by a single fixture in this present work. The new fixture and supporting plates have been designed with the help of SOLID WORKS software. By means of this fixture, total production time is reduced to 78.6% and hence production rate is also improved significantly.**

***Keywords*—Casing, Suction bracket, Combination fixture, Production time, Production rate**

I. INTRODUCTION

Fixture is a part of a machine which holds the work piece during operation with various technical and special arrangements. It is developed with various principles based on the machine, type of component and machining parameters like feed, speed and depth of cut. It is a device for locating, holding and supporting a work piece during a manufacturing operation. It is designed for applications where the cutting tools cannot be guided as easily as a drill. It can be used in almost any operation that requires a precise relationship in the position of a tool to a work piece. Fixtures are essential elements of production processes as they are required in most of the automated manufacturing, inspection, and assembly operations [1-4].

Modern era production demands computer operated machine tools for higher production reliability and accuracy [5-6]. It necessitates the use of jigs and fixture for easy loading and unloading of work piece hence saving time to increase the productivity. Jigs are used for directing tool in correct position and fixture normally mounted on machine table provide secure locating and supporting work piece during machining operation [7]. Locating refers to dimensional and positional relationship between work piece and cutting tool. Various forces acting upon work piece during machining operation demands clamping in position once work piece is correctly located.

Most fixturing systems reviewed in this paper had been developed for a specific purpose. Satya pal Vaghela and Abhishek Singh [8] have developed a fixture set up for rear cover in agriculture tractor and reduced cycle time and increased productivity. Jakukore and Raut [9] have developed rotary cage fixture having ability to rotate about its axis and able to fix the component at any angle for heavy component. Vinay et al [10] have designed a fixture for mounting sub assembles to perform tack welding. Kumara and Mohan Ram [11] have designed and fabriacted a lathe fixture for brake drum manufacturing companies. Patel et al [12] have designed a fixture for machining gear shifting fork. Abhilash Reddy et al [13] have optimized the fixture for Rock drill to reduce the machining cost of the component and the labour work. Soni and Mane [14] have made an attempt to design a fixture for cylinder liners honing operation to improve productivity and reduce the rejection rate on honing machine. Dongre et al [15] have analyzed the jigs and fixture used in the chassis bracket of Baja car RE60. Perez et al [16] have produced an inspection fixture for a coordinate measuring machine to reduce time and cost associated to the inspection process. Stephen Antony Predeep et al [17] have developed a adjustable type of drill bush, which enhanced the holding of work piece with variable dimension.

The authors [18, 19] have described the various developments in fixture design and the directions for future research initiatives. Bi and Zhang [20] have introduced a flexible fixture design based on the flexibility strategies. Nanthakumar and Prabakaran [21] have proposed a method to design and fabricate the multipurpose jig and fixture for the complete machining operations in a single machining centre. Adejuyigbe et al [22] have developed a heuristic algorithm to select suitable jigs and fixtures by considering the different configurations of the work piece. Nalbandh and Rajyaguru [23] have optimized fixture design through genetic algorithm in terms of fixture layout, clamping position and part deformation. Vishnupriyan et al [24] have suggested a Genetic Algorithm (GA) based optimization method to arrive a layout of error containing locators for minimum machining error satisfying the tolerance requirements and providing deterministic location.

Okpala and Okechukwu [25] have identified the numerous advantages associated with the use of jigs and fixtures in manufacturing. Leaney et al [26] have described the use and deployment of virtual fixtures, jigs and gauges to locate, align and measure features in simulation models used in the dimensional variation analysis (DVA) of assembly systems. Krishnakumar and Melkote [27] have reported that dimensional accuracy of a workpiece was influenced by the fixture layout selected for the machining operation. Choudhuri and De Meter [28] have applied locator tolerance analysis to reveal some important insights into the relationship between machined feature geometric error, locator design, and locator tolerance scheme. Tseng [29] have made a feature-based fixturing based on the 3-2-1 and the 4-2-1 fixture design principles to analyze the supporting, locating, and clamping parameters.

Even though numerous fixtures have been suggested for various purposes, a fixture for combining many operations in manufacturing industries is found to be minimal. Therefore, a combination fixture has been designed and fabricated for the reduction of production time in the pump manufacturing in this study.

II. PUMP COMPONENTS

In most of Indian pump manufacturing industries, three fixtures are used for performing machining operations like milling, drilling and tapping on the pump components like rear cover, front cover, casing and suction bracket. The components of a submersible pump are shown in Figure 1 and the details of the components are given in Table 1

ASM SP Rear Cover

ASM SP Front Cover

ASM Rear Cover

TVJ Delivery Casing

TVJ N Casing

Suction Bracket

Figure 1. Pump Components

Table 1. Details of the Pump Components

S. N o	Components	Seating Size (mm)	Maximum OD of Component (mm)	Total Length of Component (mm)
1.	ASM SP Rear Cover (1)	138	156	71
2.	ASM SP Rear Cover (2)	138	186	52
3.	ASM SP Front Cover (3)	138	186	66
4.	ASM SP Front Cover (4)	138	195	71
5.	ASM SP Front Cover (5)	138	187	74
6.	ASM SP Front Cover (6)	138	181	74
7.	ASM SP Front Cover (7)	138	181	74
8.	ASM SP Front Cover (8)	138	212	75
9.	ASM SP Front Cover (9)	138	197	72
10.	ASM SP Front Cover (10)	138	156	72
11.	ASM SP Front Cover (11)	138	156	72
12.	ASM SP Front Cover (12)	138	232	99.5
13.	ASM Rear Cover (1)	175	229	57
14.	ASM Rear Cover (2)	175	229	57
15.	ASM J Rear Cover (3)	178	200	61
16.	ASM J Rear Cover (4)	178	200	61
17.	TVJ Delivery Casing	122	216	92
18.	TVJ N Casing	140	232	49
19.	Suction Bracket	37	50	144

III. DESIGN AND FABRICATION OF COMBINATION FIXTURE

3.1 Material Specification of Fixture Parts

Material : Mild steel
Grade : IS 2062
Product form : Forging as per drawing
Treatment condition :Normalised
Finishing : As per IS 3469
Chemical composition : Carbon (C) = 0.25%
Manganese (Mn) = 1.5%
Sulphur (S) = 0.05%
Phosphorus (P) = 0.05%
Silicon (Si) = 0.4%
Hardness : 110 – 170 BHN
Ultimate tensile strength : 410 - 530 N/mm2

3.2 Design Parameters

Height of the centre plate : 268 mm
Width of the centre plate : 299 mm
Thickness of the centre plate : 24 mm
Length of the base plate : 453 mm
Width of the base plate : 299mm
Thickness of the base plate : 23mm

Height of the cylinder vertical plate : 211 mm
Width of the cylinder vertical plate : 180 mm
Thickness of the cylinder vertical plate: 20 mm
Length of the cylinder gazette plate : 211 mm
Width of the cylinder gazette plate : 46 mm
Thickness of the cylinder gazette plate: 18 mm
Length of the gazette plate : 294mm
Width of the gazette plate : 70mm
Thickness of the gazette plate : 20mm

3.3 Block Diagram

Based on the dimensions of the pump components, a combination fixture was designed [30, 31] with the following parts, which are clearly indicated in the block diagram shown in Figure 2.

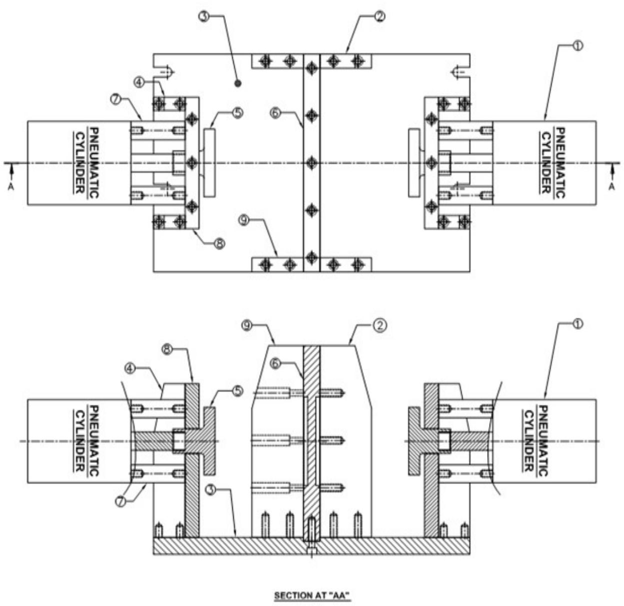
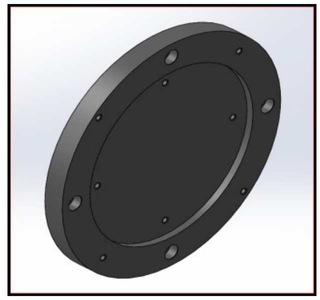


Figure 2. Block Diagram

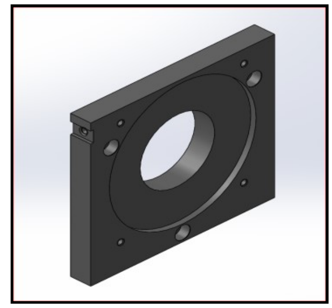
1. Pneumatic cylinder
2. Gazette plate – R
3. Base plate
4. Cylinder gazette plate
5. Clamp
6. Centre plate
7. Cylinder supporting rod
8. Cylinder vertical plate
9. Gazette plate – L

3.4 CAD Model

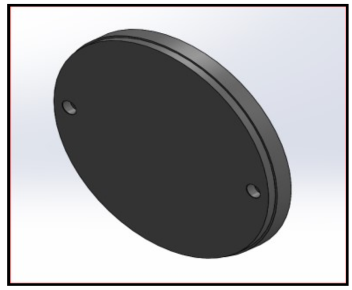
The seating plates for clamping the pump components were developed with SOLID WORKS software. The CAD models of seating plates are shown in Figure 3. CAD model for all parts required for combination fixture was developed with the help of SOLID WORKS software. All models were assembled using assembly design module. Assembled view of combination fixture is shown in Figure 4.



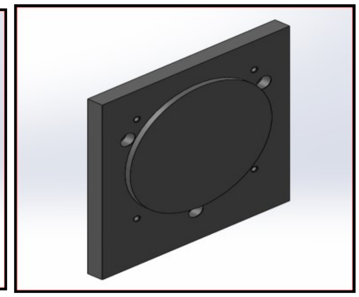
ASM SP Rear Cover



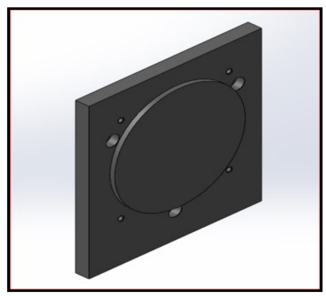
ASM SP Front Cover



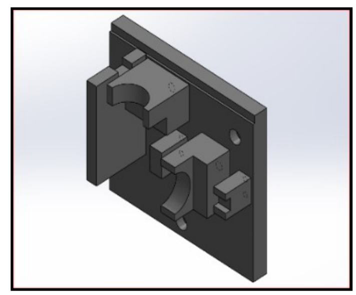
ASM Rear Cover



TVJ Delivery Casing



TVJ N Casing



Suction Bracket

Figure 3. Seating Plates

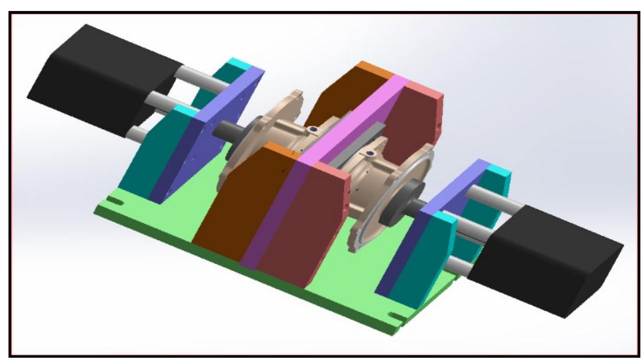


Figure 4. CAD Assembly for Combination Fixture

3.5 Fabrication

Pneumatic cylinder, gazette plates, base plates, cylinder supporting rods, cylinder vertical plates and supporting plates were fabricated. A combination fixture shown in Figure 5 was developed by assembling the above said components. It was used for for clamping the pump components and performing machining operations like drilling, tapping and milling were carried out on the pump components with the help of a CNC machining centre.

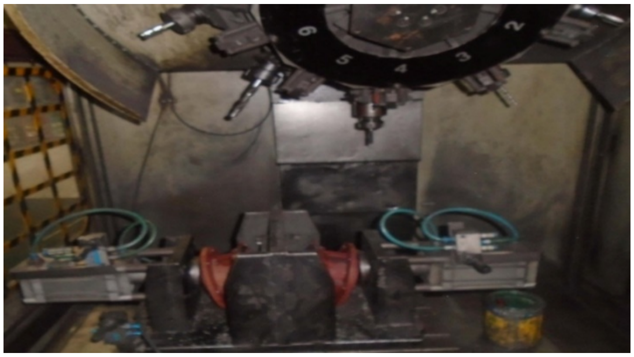


Figure 5. Combination Fixture

IV. RESULTS AND DISCUSSION

A comparison was made on production time of pump components with and without combination fixture and given in Table 2 and Table 3 respectively. The comparison of production time is shown in Figure 6.The benefits of the combination fixture is given in Table 4.

Table 2. Production Time (without combination fixture)

Component Name	Processes	Machine Type	Setting Work	Setting Time (Min)	Machining Time (Min)	No. of Components	Production Time (Min)
ASM SP Rear& Front Cover	Drilling, Tapping	CNC	Fixture changing, pneumatic clamping, tool setting & program setting	40	2.55	12	70.60
ASM Rear Cover	Milling, Drilling, Tapping	CNC		40	4.10	4	56.40
TVJ Delivery Casing	Milling, Drilling	Con-ventional		120	2.22	1	122.22
TVJ N Casing	Milling, Drilling,	Con-ventional		120	2.22	1	122.22
Suction Bracket	Milling, Drilling	CNC		60	2.58	1	62.58
						Total Production Time	434.02

Table 3. Production Time (with combination fixture)

Component Name	Processes	Machine Type	Setting Work	Setting Time (Min)	Machining Time (Min)	No. of Components	Production Time (Min)
ASM SP Rear & Front Cover	Drilling, Tapping	CNC	Only changing the seating plate	10	2.15	12	35.80
ASM Rear Cover	Milling, Drilling, Tapping	CNC		10	3.20	4	22.80
TVJ Delivery Casing	Milling, Drilling	CNC		10	1.38	1	11.38
TVJ N Casing	Milling, Drilling,	CNC		10	1.40	1	11.40
Suction Bracket	Milling, Drilling	CNC		10	1.53	1	11.53
						Total Production Time	92.91

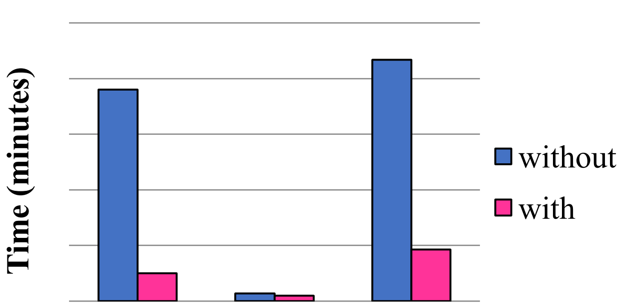


Figure 6. Comparison of Production Time

Table 4. Benefits of Combination Fixture

	Before	After	Benefits
Production Time (min)	434.02	92.91	Time of 341.11 minutes is saved and 78.6% productivity is increased
Rejection Rate	4 No's / Month	0 No's / Month	Zero Rejection
Operator's Comfortability	Multiple fixtures	A combination fixture with seating plates	Operator's fatigue is reduced

V. CONCLUSION

This paper outlines the design and development of a combination fixture for industrial applications. It shows that the loading and unloading of components are so easy and also number of the operations like milling, boring, drilling and tapping can be done in a single set up. The combination fixture leads to reduction in production time, reduction in production cost, flexibility in machining and overall improvement of the product quality.

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