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Design and Analysis of Fixture for Indexing and Machining the Steam Distribution Manifold

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Abstract-The industrial development is based on the maximum production rate to change in the competitive world. The main objective of the project is to increase the production rate and to reduce the cost of manufacturing. Fixture is a work holding device used for performing various machining operations in the work piece. Manifold is the basic component of Steam Distribution Assemblies. In the company REVOLUTION VALVES the machining of the manifold was done in vertical machining center (VMC), which takes more setting time and high labour cost. This made manufacturing cost of the component was very expensive and reduced the production rate. To overcome these difficulties we need to design a fixture to machine the Manifold. Manifold contains holes in different angles and need to do face mill, drill & tapping. As per the concern it needs to design a Fixture that can hold the component on a vertical machining center (VMC). During machining several problems arises, such as more time for setting the component in vertical machining center (VMC), unable to achieve the expected accuracy in a systematic manner & sustaining the same accuracy level also difficult. Suitable methodology was followed to design a fixture for holding the work piece and performing various machining operations in the component. With the final phase, all the complications that arose during the previous phases were solved and the design was made feasible, resulting in a considerable reduction in setting time and increasing the production rate.

Index Terms-Fixture, Vertical Machining Center (VMC), Manifold, Steam Distribution Assemblies

1. INTRODUCTION

Growth of an industry depends on its productivity. Increase in the rate of production implies the growth of the industry. Therefore, continuous study to increase the productivity plays a vital role in the industrial development.

Consider the machining of a work piece. Suppose it needs Thirty minutes to complete an operation on a particular machine. If we could complete that work in Twenty Nine minutes, it would be considered as a significant achievement as far as production is concerned. There may be thousands of work pieces to be machined and hence, each and every minute saved per work piece means a lot for an industry. Every industry will be ready to spend Lakhs of Rupees to get at least a minute saved in a machining operation.

The main objective of the project is to increase the production rate and to reduce the cost of manufacturing. Fixture is a work holding device used for performing various machining operations in the work piece. Manifold is the basic component of Steam Distribution Assemblies. In the company REVOLUTION VALVES the machining of the manifold was done in vertical machining center (VMC), which takes more setting time and high labour cost. This made manufacturing cost of the component was very expensive and reduced the production rate. To overcome these difficulties we need to design a fixture to machine the Manifold. Manifold contains holes in different angles and need to do face mill, drill & tapping. As per the concern it needs to design a Fixture that can hold the component on a vertical machining center (VMC)

Consider the same operation being completed on a Vertical machining Center. This would help in reducing the operational expenses due to the duration of setting and worker expenses. This would result in a higher profit level.Suitable methodology was followed to design a fixture for holding the work piece and performing various machining operations in the component.

In Steam Distribution Assemblies as shown in figure 1 and 2 the multi stage steam distribution manifold distributes the steam supply through valves from a particular location. Standardizing components and centralizing their location simplifies installation and cost savings. Since routine maintenance is faster. Insulation can also be provided and can be a major savings.

Schematic layout of Steam distribution assemblies

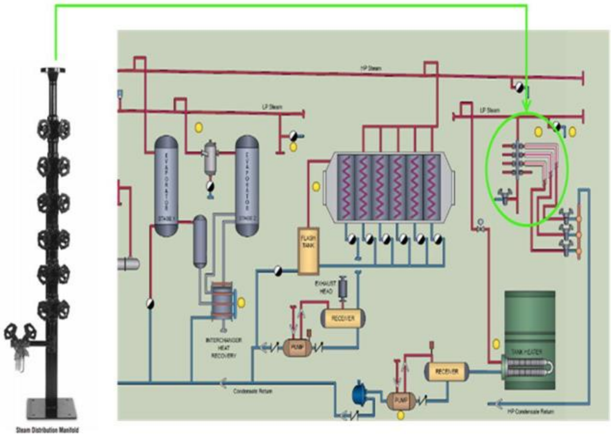

Fig 1: Schematic Layout

Manifolds are mainly used in steam distribution assemblies (MSD- Multi Stage Distribution).

Fig 2: MSD- Multi Stage Distribution

2. PROBLEM FORMULATION

Based on the present industrial structure and setup, and based on the expenses suffered, the problem was formulated as follows:

- Identify and solve the various complications involved with the particular operational steps.
- Formally submit the design to the project supervisor and the bench of jury.

2.1. Problem Description

Manifold is a tight fit assembly for a tail Steam Distribution in utility Boilers. Since to ensure more safety assembly, close tolerance level and more surface finish are required. Number of machining operations need to be done in the manifold as shown in figure 3 Milling. Drilling and Tapping. To perform these operations it takes more of time for setting the component in Vertical Machining Center (VMC). Unable to achieve the expected accuracy in a systematic manner & sustaining the same accuracy level is also difficult.

2.2. Productivity

- 4 Hours per component (Both Setting & Machining)
- 50 numbers only per month / per one machine.

Fig 3: Machined Manifolds

3. OBJECTIVE

To design a fixture for indexing and machining the component and to simplify the setting process & various machining operations, so that Production rate is increased. Material of the component: ASTM A105 Forging (Forged grade Carbon Steel). The Various machining operations such as Drilling, Milling & Tapping are to be done in the component. In existing method the setting time and machining time is more and the machining rate is minimum. To overcome the issues we have designed a fixture.

4. JIGS AND FIXTURES

According to Mr. G.R Nagpal, in “Tool Engineering and Design”, ISBN No. 81-7409-203-X, Jigs and fixtures are designed to hold, Support and locate the work pieces to ensure that each part is machined within the specified limits. Use of jigs and fixtures provides a faster and profitable method of manufacturing in which components can be quickly positioned in the correct relationship to the cutting tool.

Fixture: It is a device which locates and holds the component for a specific operation. It does not guide and cutting tool.

Jig**:** It is a device which is used to hold and position the work piece. In addition it provides some means for guiding and cutting tool.

4.1. Design steps

- While designing jigs and fixtures, following steps may be considered:
- To inspect the drawing of the component and to note the dimensions.
- To decide the sequence of machining operations.
- To decide the location systems.

- To decide the clamping system.
- To fix the method of positioning the cutting tool relative to the work piece.
- To decide the safety devices to be used.

4.2. Location

The work piece must be accurately located to establish a define relationship between the cutting tool and some points or surface of the work piece. The locating device should be so designed that each successive work piece when loaded and clamped will occupy the same position in the work holding device mainly depend on nature of work piece and requirements of the metal removing operation.

In the design of jig and fixtures the location of the component is very important aspect as the correct location influences the accuracy of the finished product.

4.3. Basic Rules for Location

The basic rules for locating the component are follows:

Locators should be as spaced as far as possible thus using fewer locators and insuring complete contact over the locating.Locators should be positioned to contact the work on a machined surface.Locator provided should be fool proof i.e. the component can only be located into fixture in the corrected position. Location features should be swarf traps and should have clearance provided where necessary to clear machining burrs.Locating devices should reduce the degrees of freedom to zero with no redundant location features.

5. CLAMPING

The various forces acting upon the work piece during a machining operation necessitate a means of clamping it in the position after it has been correctly located. The method of clamping will depend upon the type of locating and clamping methods and devices will depend upon the machining operation and the configuration of the part.

6. DEGREE OF FREEDOM

A body in space has twelve degrees of freedom i.e. it is capable of moving into the space in the twelve different directions. The body can move in either of two opposed directions along three mutually perpendicular axes and may rotate in either of two opposed directions around each axes clockwise and anti-clockwise. Each direction of movement is considered as once degree of freedom. Thus there are twelve degrees of freedom for any work piece in space.

6.1. Principles of Location

Principle is also known as six point location principle which is used to constrain or prevent the body from moving in any direction along three axes XX, YY, and ZZ By providing six locating pins-three in a base plane, two in a vertical plane and one in a perpendicular to the first two the nine degrees of freedom are controlled.

The various locating pins provided arrest the degrees of freedom explained as follows.

Pins A, B, C will restrict the body from rotating about X and Y axes and the body cannot move downward along Z axis. Thus, 5 degrees of freedom will get restricted. Pins D and E whose faces are in a plane parallel to the plane containing the X and Z will prevent the body from rotating about the Z axis and also the body cannot move along the Y axis in the direction of freedom 8. Thus degrees of freedom number 6, 7, and 8 will get restricted.

Pin F will be able to restrict the freedom degree of 9.Three degrees of freedom 10, 11 and 12 will remain unrestricted. These three degrees of freedom can be restricted by providing three more pins but then the pins will entirely enclose the work piece which is not desirable and thus the degrees of freedom 10, 11 and 12 may be restricted by means of clamping devices which also may serve to resist the forces generated during metal cutting.

6.2. Fixture

A Fixture is a type that expedites locating and clamping the work piece repetitive on multiple interchangeable parts by acting as a clamp into the precise location of each machining surface.

Since the widespread penetration of the manufacturing industry by CNC machine tools, in which servo controls are capable of moving the tool to the correct location automatically

7. SELECTION OF MATERIAL

7.1. Grey Cast Iron

Grey iron, or gray iron, is a type of cast iron that has a graphitic microstructure. It is named after the gray color of the fracture it forms, which is due to the presence of graphite. It is the most common cast iron and the most widely used cast material based on weight.

It is used for housings where tensile strength is non-critical, such as internal combustion engine cylinder blocks, pump housings, machine tool bases, valve bodies, electrical boxes, and decorative castings etc.

Composition details

Nominal composition	-C 3.4, Si 1.8, Mn 0.5
Form and condition	- Cast
Tensile strength [ksi]	- 50
Elongation [% (in 2 inches)]	- 0.5
Hardness Brinell scale	- 260

7.2. EN8

EN8 is usually supplied untreated but can be supplied to order in the normalized or finally heat treated which is adequate for a wide range of applications. EN8 is a very popular grade of through-hardening medium carbon steel, which is readily Machin able in any condition. EN8 is suitable for the manufacture of parts such as general-purpose axles and shafts, gears, bolts, clamps and studs. It can be further surface-hardened typically to 50-55 HRC by induction processes, producing components with enhanced wear resistance.

EN8 in its heat treated forms possesses good homogenous metallurgical structures, giving consistent machining properties. It is recommended that larger sizes of EN8 are supplied in the untreated condition, and that any heat treatment is carried out after initial stock removal. This should achieve better mechanical properties towards the core. It is available as normalized or rolled and is supplied as plate, round hot rolled, hexagon, flats, square and round drawn or turned.

080M40 (EN8) Chemical composition

Carbon	-0.36-0.44%
Silicon	-0.10-0.40%
Manganese	-0.60-1.00%
Sulphur	-.050 Max
Phosphorus	-0.050 Max

8. FEATURES OF INDEXING FIXTURE

- Indexing the whole fixture to required angle for position the face Which need to be machined
- Bearing Housing is supporting at other end to avoid over hanging
- No need to remove the component from fixture until the entire operation is complete
- Possibility to automate the indexing in a periodic manner for each face machining
- User friendly Clamping & locating by using smart clamps & V-Block Locators

9. MODELS OF MAJOR ELEMENTS

9.1. Assembly of Fixture

The modeled assembly fixture with multistage manifold is shown in figure 5 with considering all degrees of freedom for machining features.

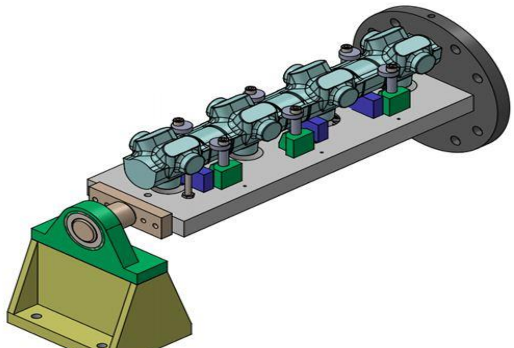

Fig 5: Modeled Isometric View

9.2. Indexing Plate

The indexing plate sown in figure 6,7 is fixed with the rotary table of the machine. One end of the base plate has been connected to the indexing plate. It has been made by EN8.So manifold can be indexed according to the operations. It also shares the weight of base plate and component. According to the requirements dowel holes, thread holes have been provided. Indexing will takes place as per the part program done with the machine.

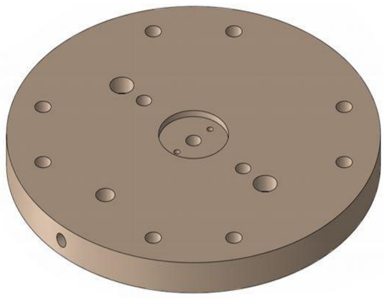

Fig 6: Indexing Plate - Isometric View

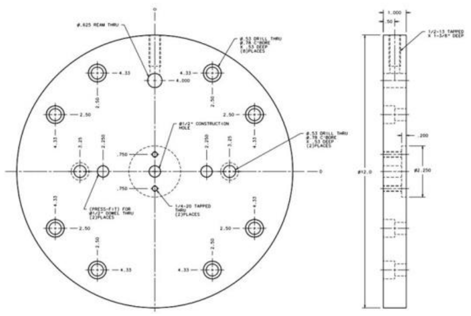

Fig 7: Indexing Plate drawing

9.3 Base Plate

The important part of the fixture as shown in figure 8 holds the total weight of the component and other things such as clamps, and fasteners. It is made by cast iron and its one end is connected to rotary indexing plate and another end is connected to the bearing housing. It can able to index according to the machining demand. On this plate the manifold will be clamped linearly by the use of Clamps, washers, bolts and nuts

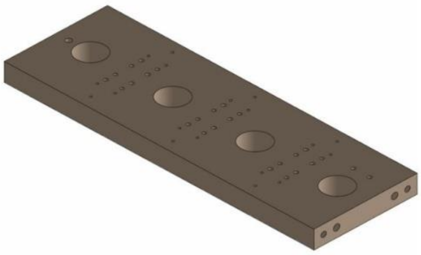

Fig 8: Base Plate - Isometric View

9.4 Bearing Housing

It supports the one end of the bearing housing shown in figure 9 allows the rotation of base plate. Base plate has been made by cast iron. In that a roller ball bearing has been fixed. So the rotation becomes very easy. The rotation is allowed on both directions. Bearing housing has been fixed rigidly on the machine table by bolt and nut. So it can able to bear the machining vibrations, shocks etc,

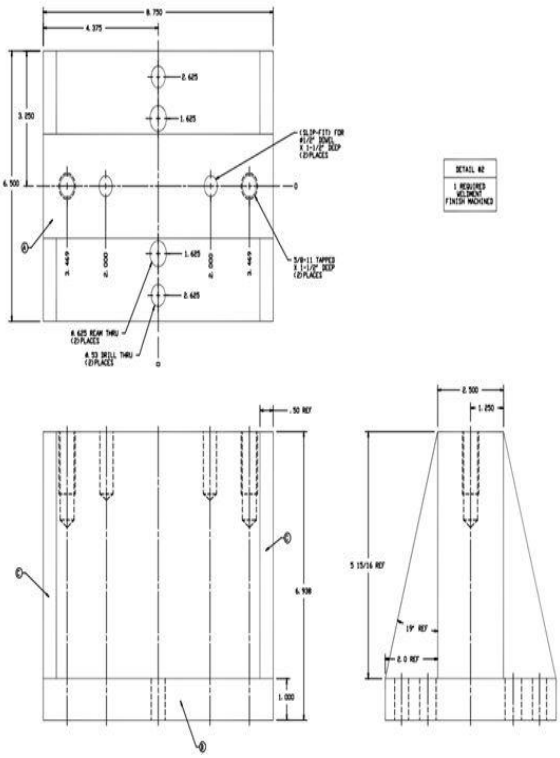

Fig 9: Bearing Housing

The details of various fixture components and its material grade specification are mentioned in table

Table 1: Bill of Material

PART NO.	DESCRIPTION	MATERIAL	QTY.
1	Fixture Base	GCI-25	1
2	Jergen - Receiver Bushing	EN 8	6
3	Indexing Plate	EN 8	1
4	Jergen Primary Liner	EN8	8
5	Butting Pin	SS	4
6	V Block	EN8	12
7	Jergen Ball Shank	EN8	6
8	Washer	EN8	6
9	Clamp Block	1018 CS	6
10	Manifold Clamp - single bar stock	EN 8	6
11	M - 10 x 1.5 x 80 Hex SHCS	ALLOY STEEL	6
12	Key	1018 CS	4
13	Stud M10 x 100	ALLOY STEEL	4
14	M - Hex jam nut, M10 x 1.5	ALLOY STEEL	4
15	Hex jam nut, M8 x 1.25	ALLOY STEEL	12
16	M - 4 x 0.7 x 16 Hex SHCS	ALLOY STEEL	18
17	Counter Sunk Screw M6 x 20	ALLOY STEEL	12
18	Bearing Housing	GCI-25	1

The cycle time and cost parameter for the existing method for machining one multi stage distribution manifold is given in table 2.

Table 2: Cost Comparison

1.1. Cost analysis

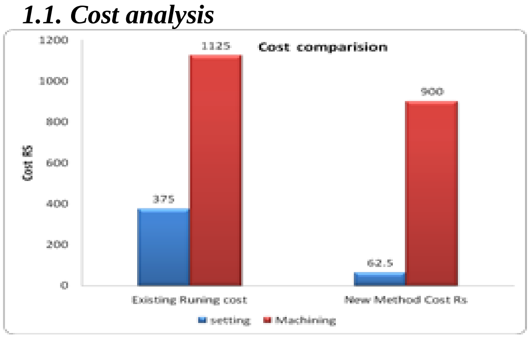

Fig 11: Cost Comparison

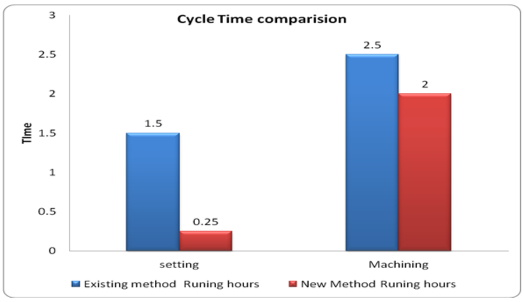

Fig 12: Cycle Time Comparison

Parameter	Cycle time / cost parameters for Existing method			Cycle time / cost parameters of new method			Saving (Rs)
	Time taken (Hrs.)	Cost per Hr (Rs)	Cost (Rs)	Time taken (min)	Cost per hour (Rs)	Cost (Rs)	
Setting time	1.5	250	375	0.25	250	62.5	312.5
Machining time	2.5	450	1125	2	450	900	225
Total machining cost per component (rupees)			1850			1150	537.5

2. CONCLUSION

The drilling, milling and tapping operations required to be completed on the manifold leads to more setting time, labour cost etc. It was preferred by the industry to transfer the milling, drilling and tapping operations to the Automatic machines. Thus the designing of a suitable fixture was undertaken to facilitate the transfer of the milling, drilling & tapping operations on the Manifold to the Vertical Machining Center.

The main challenges in the design process was to design the fixture so as to complete the milling, drilling & tapping operations on the manifold at various angles, while also avoiding manual setting on fixture. The final design successfully saw the fulfillment of all the challenges. It incorporated the principle of tilting the work to the required angles while keeping the fixture fixed on the bed of the machine.

Close tolerance can Achievable, able to meet the required surface finish & safety assembly. Interchangeability and repeatability leads to mass production. Cost saving per new method is Rs.530/Component. It reduces the production cycle time so increases production capacity. Semi-skilled operators can be assigned to the work, so it saves the labour Cost. Operators' working becomes comfortable as his efforts in setting the work piece can be eliminated drastically.

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