International Journal of Science and Research Archive

eISSN: 2582-8185

Cross Ref DOI: 10.30574/ijsra

Journal homepage: https://ijsra.net/

IJSRA

(Research Article)

Design, analysis and fabrication of hydro fixture for testing of 32" and above size valve

Sudhansu Sekhar Das * and M Sudhahar

Department of Mechanical Engineering, PRIST Deemed to be University, Vallam Thanjavur, Tamilnadu, India.

International Journal of Science and Research Archive, 2023, 08(01), 1039–1049

Publication history: Received on 03 January 2023; revised on 14 February 2023; accepted on 17 February 2023

Article DOI: https://doi.org/10.30574/ijsra.2023.8.1.0170

Abstract

A hydrostatic test is a way in which pressure vessels such as pipelines, plumbing, gas cylinders, boilers and fuel tanks can be tested for strength and leaks. The test involves filling the vessel or pipe system with a liquid, usually water, which may be dyed to aid in visual leak detection, and pressurization of the vessel to the specified test pressure. Pressure tightness can be tested by shutting off the supply valve and observing whether there is a pressure loss. The location of a leak can be visually identified more easily if the water contains a colorant. Strength is usually tested by measuring permanent deformation of the container. Hydrostatic testing is the most common method employed for testing pipes and pressure vessels. Using this test helps maintain safety standards and durability of a vessel over time. Newly manufactured pieces are initially qualified using the hydrostatic test. They are then re-qualified at regular intervals using the proof pressure test which is also called the modified hydrostatic test .Testing of pressure vessels for transport and storage of gases is very important because such containers can explode if they fail under pressure. Hydrostatic tests are conducted under the constraints of either the industry's or the customer's specifications, or may be required by law. The vessel is filled with a nearly incompressible liquid - usually water or oil - pressurized to test pressure, and examined for leaks or permanent changes in shape. The test pressure is always considerably higher than the operating pressure to give a factor of safety.

Keywords: Dyed; Pressurization; Test pressure; Valve; Colorant; Pressure vessels; Hydrostatic test; Operating pressure; Factor of safety

1. Introduction

With the technological evolution of "power plant piping" the size of valves getting bigger now a day according to temperature and pressure parameters. The valves in hydro lines, CRH lines, HRH lines main steam lines is above 24" and it must have some good strength and good life and others technical parameters. Before ensuring completion of valves, it need to be tested. Hydro test is a test which can check the strength of valves and leaks in valves. In general, the hydro test conducted is 1.5 times of the required working pressure of valve according to ASME standard. The procedure of hydro testing comprises the plugging both inlet and outlet pressurizing it through a port. The plugging may have enabled by threaded plunger or clamping it by hydraulic operated plunger or by a fixture. But bigger size valves prefer threaded plunger type hydro testing which takes extensive hard work due to bigger size of plunger as well as unnecessary pre and post hydro machining. The current study focuses the preparation of hydro fixture which can automate clamping and decamping of inlet and outlet allow fluid filling inside the valve and pressurize it. The fluid may have coloring agent which may have identified easily while leak.

1.1. Problem identification

The testing of the valve of sizes 36-150-WCB Gate valve,750-1500 CRHIV, 32-150 QCNRV was conducted by fixing two threaded plunger of respective valve sizes at both inlet and outlet end of the valve and then pressurizing it according to the requirement. The threaded plunger was very heavy and tightened with help of crane is needs more workers as well

* Corresponding author: Sudhansu Sekhar Das

as time-consuming Operation. So, this existing method renders, Costlier: Machining of thread at each end was only for the hydro testing. Unsafe condition: The handling of these heavy plungers is by support of crane so there is a chance of unsafe conditions. Wastage: Wastage of Manpower as well as it is very time-consuming process. Difficult: The testing operation is very difficult.

So, this problem studied in all respect and decided to make a solution of these problem from all angle. I.e., Reduce Cost, improving safety and reducing wastage of resources. An idea of manual fixture for above valves came from the geometry of hydro testing bench used for small valves.

2. Methodology

Methodology is a systematic approach for realization of total task. It consists of following details:

2.1. Study of component

The study of component is the most important and the first step for the designer. The component drawings carefully scrutinized to extract the maximum possible information. The important information available is the critical dimensions, locating and clamps areas.

2.2. Geometric model of component

Geometric modelling of component done using Co- Create considering all the critical dimensions.

2.3. Systematically design calculations

It carried out to determine the various design parameters that determine cutting force induced on the component during milling operation.

2.4. Selection of fixture materials

The material used in the manufacturing of fixture varies depending on the applications. Proper material selection and proper combination of alloys in varying percentages are required for finished fixture.

2.5. Solid modelling of fixture

3-D modelling of entire Component is done using Co-Create software. For the better understanding of 2D drawings and visualization, modelling has done. The required dimensions determined by calculation, which used during modelling of the tool.

2.6. Design criteria/material details

Design of base weldment and side block with roller housing

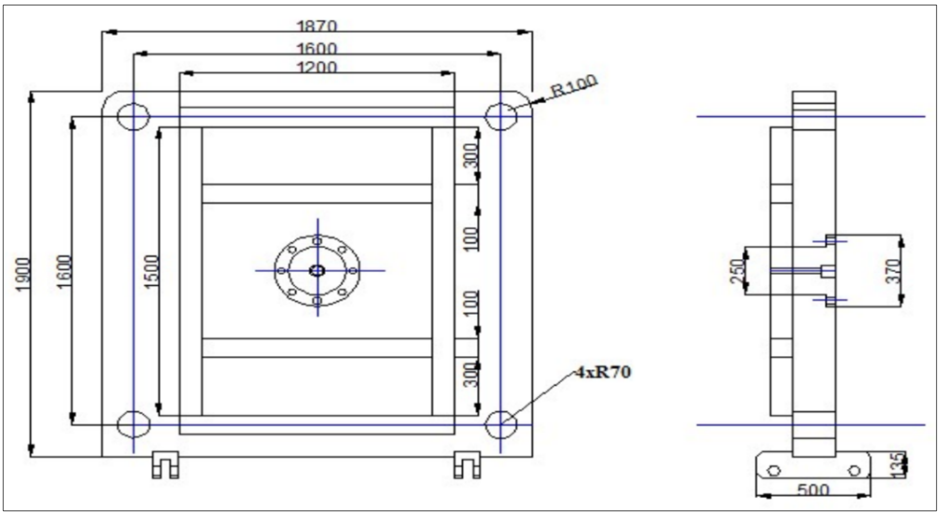

Figure 1 Design of base weldment and side block with roller housing

2.6.1. Tie rod

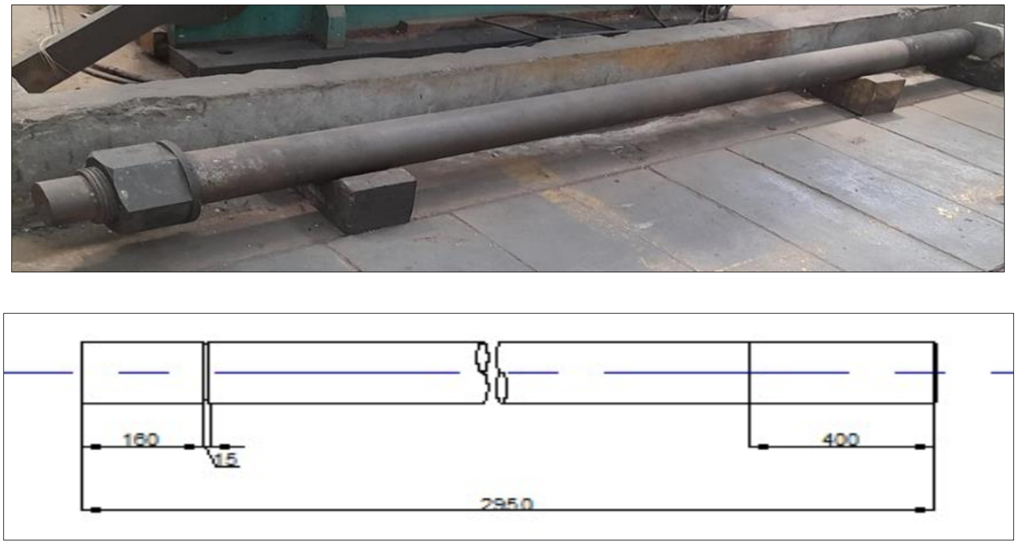

Figure 2 Tie Rod

2.6.2. Collar nut

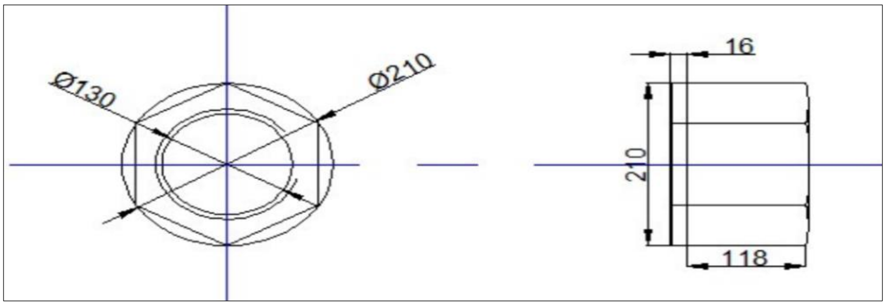

Figure 3 Collar nut (front and side view)

2.6.3. Hydro testing plunger

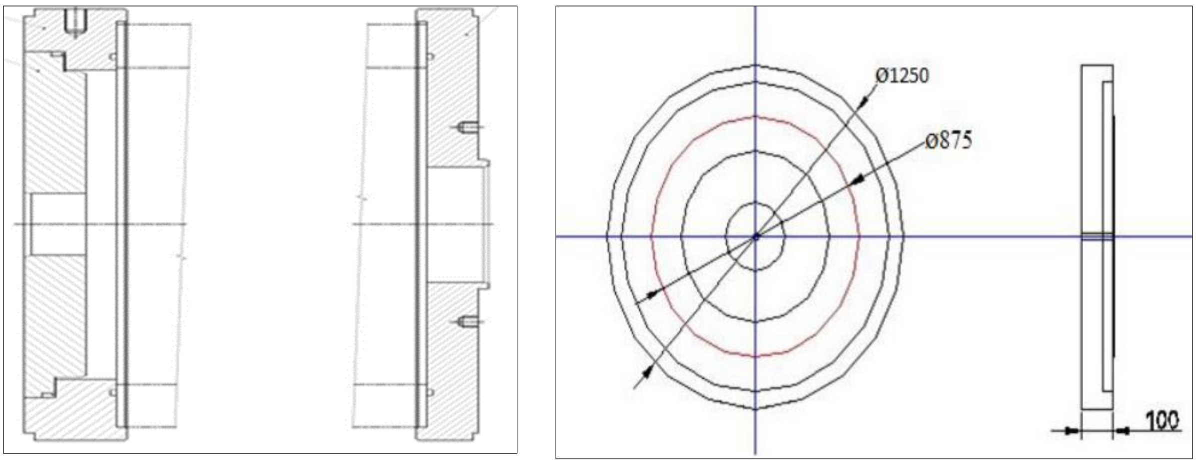

Figure 4 Hydro testing plungers

2.6.4. Front and side view of the fixture

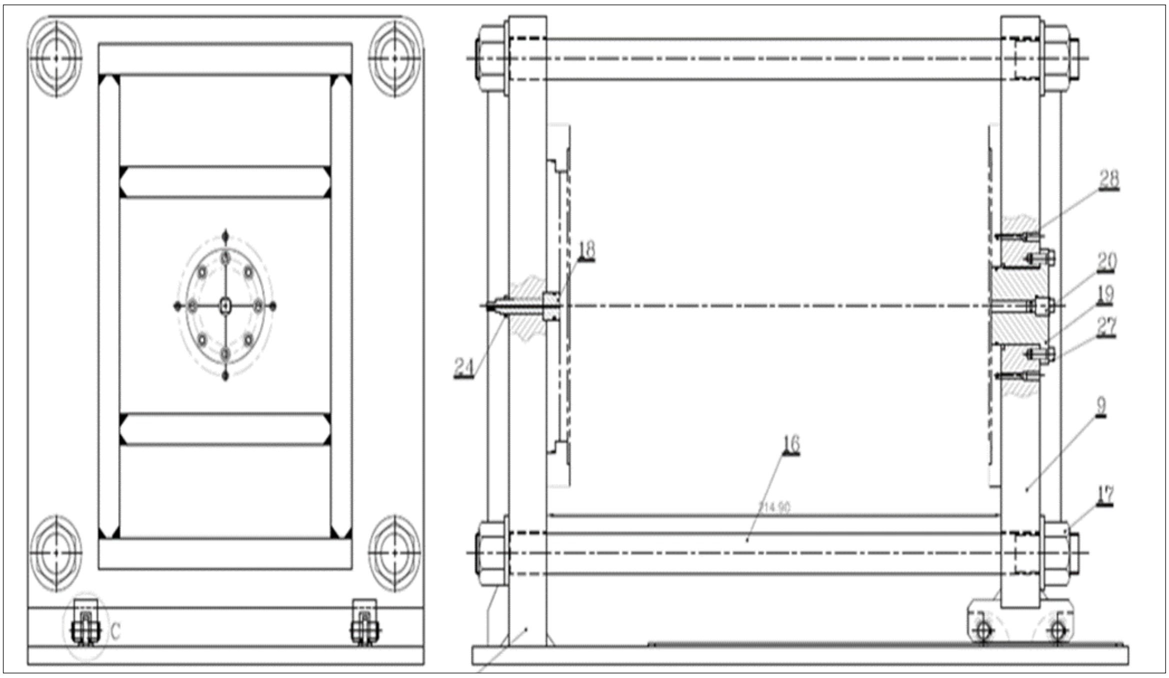

Figure 5 Sealing plate

Table 1 Types of valve and required dimension for consideration of fixture fabricatiion

SL.No	VALVE TYPE	VALVE SIZE	ID of valve	OD of Valve	Length	ØA	ØB	ØC	ØD
1	CRHNRV	34"/C600 SPL	850	980	2090	875	925	945	1022
	GV	38"/C600 BW	875	1035	1999				
	GV	36"/C150	876	950	1020				
	QCNRV	36"/C150	890	960	2010				
2	GV	32"/C600	760	853	1796	700	800	820	875
	CRHNRV	32"/C900 SPL	740	870	2110				
	RIV	800 mm/C600 WCC	745	868	1756				
	CRHNRV	32"/C600	770	870	2010				
	GV	32"/C150	772	848	1084	740	820	840	856
3	QCNRV	32"/C150WA	790	852	1960				
4	FV	38"/C300	940	1020	2099	860	975	1000	1025
5	CRHNRV	24"/C600	570	760	1660	500	620	636	765
6	GV(FL)	36"/C150 FLANGED	876	1169/1022	811	800	915	938	1175

2.7. Designed size and taken size of the parts.

Table 2 Major component size and its factor of safety

S. No	Parts Name	Designed size (mm)	Taken size (mm)	Factor of safety
1	Side block thickness	175.51	183	4
2	Diameter Tie rod	188.81	190	6

3. Bill of materials

Table 3 Material requirements

S. No	Part name	Material	No. Of pieces
1	Base Weldment	Carbon steel	1
2	Block with roller housing	Carbon Steel	2
3	Tie Rod (T r 130×8 –7e)	SA193 B7	4
4	Collar Nut (T r 130×8 –7H)	SA193 B7	4
5	Connector	SA193 B7	4
6	View Port Plug	SA193 B7	4
7	Dummy plug	SA193 B7	4
8	Bush	SA193 B7	4
9	Spacer	SA193 B7	4
10	Drive shaft	SA193 B7	4
11	Lock Nut	SA193 B7	4
12	Double row Cy. Roller bearing	Chrome Alloy	4
13	External clip	Chrome Alloy	4
14	Allen screws M30×80	SA193 B7	4

3.1. Experimental details

3.1.1. General consideration of scope for testing

Hydro testing plungers

Single Action Plunger with sealing plate on one side considered for easiness in handling and operating.

Plunger sizes are arrived optimally by considering various combination of valve sizes that are to be hydro tested. 62percent of the valves covered in two plunger sizes, which is an advantage as no need to change the plunger for those sizes.

Load acting on the plunger = Test pressure load

Load acting on the valve = 5% of test pressure load

3.1.2. We considered the following valves

32-150 class gate valve,36-150 class gate valve,750-1500 class CRHIV,32-600 class CRHNRV,38-300 HM FLAP valve.

Hydrostatic shell test pressure = 152 - 159 kg/cm^2 depending on material / group.

Maximum test pressure = 170 kg/cm^2

ID of valve = 865mm

OD of valve = 1018mm

Sealing diameter = 925mm

Sealing groove dimensions followed as per LS-Mechanic, Germany. (Sealing plates for TOA test bench now in operation).

Total load acting because of the test pressure calculated by

$$\text{Load} = \text{Area x Pressure}$$

$$L = \frac{\pi}{4} \text{ x } d^2 \text{ x } 170 \text{ kg}$$

Therefore,

Load acting = $\frac{\pi}{4}$ x 92.5^2 x 170 (Kg f = 9.81N)

= 1142409.75 Kg

= 11207039.65 N

= 11.21 MN.

3.1.3. Design of side blocks

Side blocks are material is taken as mild steel

As per ASME section II-part D tensile strength of carbon steel material = 70.4 kg/mm^2

Considering Factor of safety as 4,

2 blocks at two sides are planned therefore thickness of the block is calculated by

Maximum pressure (p) = 170 kg/cm^2 or (1.7 kg/mm^2)

= 16.677 N/mm^2

Sealing diameter = 925mm.

3.1.4. Minimum thickness of the side blocks

For a flat side block are tie rod connected to the shell flange.

The value of coefficient of plunger and the side block (k = 0.162).

Therefore,

Minimum thickness of the side block calculated by

$$\text{Thickness (t)} = d\sqrt{\frac{kP}{\sigma}}$$

Working stress = Acting pressure

Ultimate stress (σ) = working stress * factor of safety

= 16.677 *4.5

= 75.05 N/mm^2

$$\text{Thickness (t)} = 925\sqrt{\frac{0.162\ X\ 16.677}{75.05}}$$

= 175.51 mm

Therefore,

Thickness of the side block (t) = 183 mm.

3.1.5. Design of safety

Longitudinal stress (σ) = P d/4t

= (1.7*925)/ (4*183)

= 2.148 kg/mm^2

Circumferential or hoop stress = P d/2t

= (1.7*925)/ (2*183)

= 4.30 kg/mm^2

The working stress is less than the strength of the material.

Designed stress is < the strength of material.

The design of the side block is safe.

3.1.6. Design of tie rod

Tie rod material taken as SA193B7.

As per ASME section II-part D tensile strength of SA193 B7 material = 70.4 kg/mm^2

Considering Factor of safety = 6

Tensile strength = 23.466 kg / mm^2

Maximum pressure (p) = 170 kg/cm^2 or 1.7 kg/mm^2

Sealing diameter = 925mm

4 Tie rods at four corners are planned therefore diameter of Tie rod is calculated by

$$\text{Tensile strength} = \frac{load\ shared\ by\ each\ tie\ rod}{Area}$$

Load = Area x Pressure

$$(L = \frac{\pi}{4} \text{ x } d^2 \text{ x } 1.7 \text{ kg.})$$

$$\text{Therefore, Load acting} = \frac{\pi}{4} \text{ x } 925^2 \text{ x } 1.7 \text{ kg}$$

= 1142410.72 kg

Diameter of bolt required for withstanding the load considering 04 bolt

Ultimate stress (σ) = working stress * factor of safety

= 1.7*6

= 10.2 kg/mm^2

Ultimate stress (σ) = $\frac{load}{Area}$

Area (A) = load/ultimate stress

$$d = \sqrt{\frac{1142410.72}{4\,(\frac{\pi}{4} X\ 10.2)}}$$

= 188.81mm

Take nearest standard size of tie rod = 190mm

3.2. Design of safety

Stress = load /Area kg/mm^2

= 1142410.72 / ($\frac{\pi}{4}$ *190^2) kg/mm^2

= 40. 29 kg/mm^2

The stress is less than the strength of the material.

Designed stress is < the strength of material

The design of the tie rod is safe.

3.2.1. Design of nut

Thread shearing stress for nut (λ) = $\frac{P}{\pi * d * b * n}$

d - Major diameter of thread

b - Base width of thread

n - No of threads engaged

$$(\lambda) = \frac{1142000/4}{\pi * 130.87 * 2.696 * 20}$$

= 12.87 kg/mm^2

Allowable shear strength of nut material is 0.9 times UTS

= 0.9 x 70.4

= 63. 36 kg /mm^2

Therefore, Factor of safety = 63.36/12.87

= 4.92

Height of nut taken more than the Diameter of bolt to avoid failure in shear.

3.3. Working principle

3.3.1. Sequence of Operational Procedure

- Remove one of the top Tie rods from the assembly.
- Loosen collar nuts on the movable block slightly.
- Push the movable block to adjust length of the valve to be tested.
- Place the plungers and V-block matching the size of the valve to be tested.
- Place the sealing ring in position.
- Place and adjust the valve in to the fixture
- Load the top tie rod and adjust.
- Use spacers if required and tight all the nuts diagonally by applying uniform torque.
- Continue pressurizing with air and check for leak.
- Open view port plug to see leak during hydro test of seat if necessary.
- After completion of hydro test, remove the valve by removing collar nuts and top tie rod.
- Remove one of the top Tie rods from the assembly.
- Loosen collar nuts on the movable block slightly.
- Push the movable block to adjust length of the valve to be tested.
- Place the plungers and V-block matching the size of the valve to be tested.
- Place the sealing ring in position.
- Place and adjust the valve in to the fixture
- Load the top tie rod and adjust.
- Use spacers if required and tight all the nuts diagonally by applying uniform torque.
- Continue pressurizing with air and check for leak.
- Open view port plug to see leak during hydro test of seat if necessary.
- After completion of hydro test, remove the valve by removing collar nuts and top tie rod.
- Remove one of the top Tie rods from the assembly.
- Loosen collar nuts on the movable block slightly.
- Push the movable block to adjust length of the valve to be tested.
- Place the plungers and V-block matching the size of the valve to be tested.
- Place the sealing ring in position.
- Place and adjust the valve in to the fixture
- Load the top tie rod and adjust.
- Use spacers if required and tight all the nuts diagonally by applying uniform torque.
- Continue pressurizing with air and check for leak.
- Open view port plug to see leak during hydro test of seat if necessary.
- After completion of hydro test, remove the valve by removing collar nuts and top tie rod.

Figure 6 Newly designed and fabricated fixture assembly for big size valve hydro testing

Weld basement, Tie rod, V blocks ,Side block, Thread less plunger, Tie rod inserting hole, Collar nut,

- Remove one of the top Tie rods from the assembly.
- Loosen collar nuts on the movable block slightly.
- Push the movable block to adjust length of the valve to be tested.
- Place the plungers and V-block matching the size of the valve to be tested.
- Place the sealing ring in position.
- Place and adjust the valve in to the fixture
- Load the top tie rod and adjust.
- Use spacers if required and tight all the nuts diagonally by applying uniform torque.
- Continue pressurizing with air and check for leak.
- Open view port plug to see leak during hydro test of seat if necessary.
- After completion of hydro test, remove the valve by removing collar nuts and top tie rod.

3.4. Testing procedure

Process of new valve assembly in hydro test:

Figure 7 38 - 600 class Gate valve hydro Testing of newly designed and fabricated fixture assembly

3.4.1. Seat test (hydrostatic)

Every valve subjected to the hydro test of the body at 1.5 times the maximum permissible working pressure at 1000 F (380C). The body should remain tight for the test duration. The test shall show no leakage, no wetting of the external surfaces and no permanent distortion under the full test pressure. No device used in testing the valve that will reduce the stress in the body. The valve shall be set in the partially open position for this test, and completely filled with test fluid. Any entrapped air vented from both ends and the body cavity via either the upper test flange with the valve axis vertical. The body vent connection with the valve axis horizontal. After venting the body, vent plugs replaced. The gland and anybody jointing deemed as part of the pressure envelope. The valves then brought to the required test pressure. All external surfaces should have dried and the pressure held for at least the minimum test duration. There shall be no visible leakage during the test duration. If leakage found, corrective action taken to eliminate the leakage and the test repeated.

3.4.2. Seat Test

When applicable every valve subjected to a hydrostatic seat test to 1.1 (times the maximum permissible working pressure at 1000 F) (380C). The seat sealing surface / closure interface shall be free from oil, grease and sealant. Depending on the valve design and size, a "varying settling in period" allowed. There shall be no visible leakage during the test period.

3.4.3. Liquid test

Hydrostatic tests shall be carried out with water at ambient temperatures, with in the range of 410F (50C) and 1220F (500C), unless the use of another liquid is agreed between the purchaser and the manufacturer. If water is used it will contain water-soluble oil or rust inhibitor. Potable water used for pressure test of austenitic stainless-steel valves shall have chloride content less than 30PPM and carbon steel valves shall be less than 200 PPM.

3.4.4. Cleaning

Austenitic and duplex stainless-steel valves and valves made of 9% nickel alloy shall be flushed with demineralized water (chloride content of 1-PPM maximum) immediately after the hydrostatic test.

3.4.5. Drying

After Hydrostatic testing, the valves should blow through using dry compressed air, followed by a visual inspection for dryness. If moisture still found, the above process repeated until visually dry.

3.4.6. Test gauges

Test gauges calibrated at intervals within six months.

4. Results and discussion

Thereby the problems associated with testing high pressure big size valves hydrostatic testing is solved by preparing a special fixture which opened up the many way for hydro testing of other types of valves.

5. Conclusion

This paper proposes a feature-adaptive method called Design, analysis and fabrication of hydro fixture for testing of 32” and above size valves. Due to this research many other sizes of valves also can be tested by using all the fundamentals and design criteria used in the research.

Compliance with ethical standards

Acknowledgments

The authors are grateful to the management of Bharat Heavy Electricals Limited, Tiruchirappalli, India, and PRIST Deemed to be University, Thanjavur for their support and consent to carry out this study.

Disclosure of conflict of interest

The authors certify that they have no Conflict of Interest in the subject matter or materials discussed in this manuscript.

References

[1] Catalogue of fixture components and fixtures (2008), (http://www.imao.biz/12.12.2008)

[2] Bayes, W.E. &Baker Jian, R. (1989). Handbook of Jig and Fixture Design, Society of Manufacturing Engineers - Technology & Engineering,

[3] Spitteler, D.; Lantiq, J.; Nee, J.G. & Smith, D.A. (2003). Fundamentals of Tool Design, Society of Manufacturing Engineers, Technology & Engineering,

[4] E. G. Hoffman, Jig and Fixture Design, 2nd edh. Delmar Publishers, Albany, NY, 1985.

[5] ANSI Y14.5M, Dimensioning and Tolerances: American National Standard Engineering Drawings and Related Documentation Practices, ASME, New York. 1982.

[6] E. G. Hoffman. Fundamentals of Tool design, Society of Manufacturing Engineers, Dearborn.

[7] P. M. Ferreira. B. Kocher, C. R. Liu and V. Chandra. AIFIX: an expert system approach to fixture design.

[8] Textbook of “DESIGN OF JIGS AND FIXTURES” – N. K. Mehta.

[9] Text book of “DESIGN OF JIGS AND FIXTURES” – Edward Hoffman

[10] Text book of “MATERIAL SELECTION IN MECHANICAL DESIGN” - Michael F. Ashby