# Design, Fabrication and Testing Of Cost Efficient Thermodynamic Steam Trap

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***Abstract* - Steam traps are automatic valves used in every steam system to remove condensate, air, and other non-condensable gases while preventing or minimizing the passing of steam. Steam has been a valuable source of power since the industrial revolution. Contrary to what people believe steam is still one of the most efficient and convenient ways of distributing high quality heat energy; however, if systems are not maintained properly they can be wasteful, inefficient and dangerous. With the never-ending cycle of steam wastage most companies fail to realize that proper steam trap testing and maintenance can reduce their fuel bills by 10-30%.This paper mainly focuses on fabrication of thermodynamic steam traps without strainer so that we can reduce maintenance cost in series boiler processing plant, eliminates internal gaskets and leak paths and reduce working space for ease of maintenance.**

***Index Terms*- Steam traps, strainer, boiler processing plant, gaskets etc.**

## I. INTRODUCTION

Steam is generated in the boiler and conveyed through piping system to the steam user. The steam pipe is usually well insulated to prevent heat loss to the environment. But in real life, heat loss still happen due to convection and radiation process. Steam travelling along the pipe line will make up to heat loss and will condense forming condensate in bottom of pipeline [1]. This condensate will exact heat from steam, thus decrease the steam temperature and more condensate will be form. If this condensate not be removed continuously, it will fill up the pipe and blocking the route of steam therefore stem trap is needed.
Steam traps are automatic valves used in every steam system to remove condensate, air, and other non-condensable gases while preventing or minimizing the passing of steam. If condensate is allowed to collect, it reduces the flow capacity of steam lines and the thermal capacity of heat transfer equipment. In addition, excess condensate can lead to ―water hammer [2], with potentially destructive and dangerous results. Air that remains after system start-up reduces steam pressure and temperature and may also reduce the thermal capacity of heat transfer equipment. Non-condensable gases, such as oxygen and carbon dioxide, cause corrosion [3].

## II. LITERATURE SURVEY

Types of steam traps
1. Mechanical traps
Mechanical traps have a float that rises and falls in relation to condensate level and this usually has a mechanical linkage attached that opens and closes the valve. Mechanical traps operate in direct relationship to condensate levels present in the body of the steam trap. Mechanical steam traps have a typical service of life of 3 years. Inverted bucket and float traps are examples of mechanical traps. [4]

2. Temperature traps
Temperature traps have a valve that is driven on / off the seat by either expansion / contraction caused by temperature differ from mechanical traps in that their design requires them to hold back some condensate waiting for it to cool sufficiently to allow the valve to open. In most circumstances this is not desirable as condensate needs to be removed as soon as it is formed. Thermostatic traps, Bi-Thermostatic traps and bimetallic traps are examples of temperature operated traps. [5]

3. Thermodynamic (TD) traps
Thermodynamic traps work on the difference in dynamic response to velocity change in flow of compressible and incompressible fluids. As steam enters, static pressure above the disk forces the disk against the valve seat. The static pressure over a large area overcomes the high inlet pressure of the steam. As the steam starts to condense, the pressure against the disk lessens and the trap cycles. This essentially makes a TD trap a "time cycle" device. [6]

## III. SELECTION CRITERIA, DESIGNING, MODIFICATION IN STEAM TRAPS

Steam trap should have positive condensate discharge with clean tight shut-off as well as discharges condensate at very close to steam temperature that ensures maximum plant efficiency. Steam trap should be compact and light weight which leads to reduction in costs.
The prototype is generated by wood crafting processes. [7]

Fig 1- Prototype (Parts) & Prototype (Assembly)

The modified thermodynamic traps can operate across their entire working range without any adjustment or change of internals. They are compact, simple, lightweight and have a large condensate capacity for their size; the prototype is shown in the figure. The designed thermodynamic traps can be used on high pressure and superheated steam and are not affected by water hammer or vibration. The all stainless steel construction offers a high degree of resistance to corrosive condensate.

### 3.1 Calculations of modified steam trap

Wall thickness as per IBR 290 can be calculated as,

$$\mathbf{T = [(W_p * D)/ (2f + W_p)] + C}$$

Where,
T = thickness in mm
$W_p$ = working pressure in kg/cm2
D = external diameter in mm (Id + 2t)
f = allowable stress in kg/cm2 as per ASME section part D= Et/1.5 = R/2.7
Et = minimum value of yield point at temperature T
R = minimum tensile strength grade of the material in kg/cm2 (at room temperature)
C = minimum positive tolerance (0.25 cm for forging and stainless steel casting) (0.5 cm for casting)

As per design,
Wp = 42 kg/cm2 at $425^{0}$
Id = 2.76 cm
f = 1757.7 kg/cm2 at room temperature
C = 0.25 cm
As per the drawing, minimum body wall thickness is 3.05
i.e 3.05 > 2.9675
Hence according to consideration design is safe.

### 3.2 Material selection

Stainless steel AISI 420 having following chemical composition was selected for manufacturing of the product as it has suitable for induction hardening. The designed thermodynamic traps can be used on high pressure and superheated steam and are not affected by water hammer or vibration. The all stainless steel construction offers a high degree of resistance to corrosive condensate.

| C | Mn | Cr | Ni | Si |
|---|---|---|---|---|
| 0.15-0.22 | 0.08-1.0 | 12-14 | - | 0.08-1.0 |

Table No 1- Showing the composition of selected material for modified steam trap

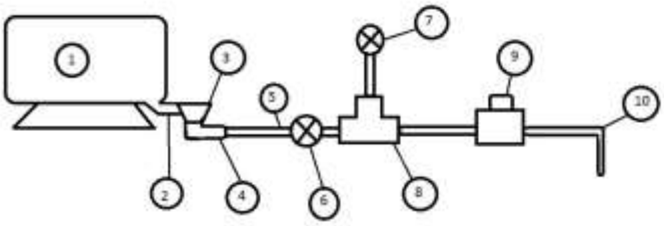
## IV. ACTUAL MANUFACTURING OF THE STEAM TRAP

The lathe is a machine tool used principally for shaping pieces of metal (and sometimes wood or other materials) by causing the work piece to be held and rotated by the lathe while a tool bit is advanced into the work causing the cutting action. The basic lathe that was designed to cut cylindrical metal stock has been developed further to produce screw threads, tapered work, drilled holes, knurled surfaces, and crankshafts. Modern lathes offer a variety of rotating speeds and a means to manually and automatically move the cutting tool into the work piece.
Using the above said machine and various manufacturing process the steam trap is manufactured, following images shows the development stages of the steam traps.

Fig 2-Shows the development stages of manufacturing of steam trap

## V. SYSTEM SETUP & COMPONENTS FOR TESTING

In order to get maximum efficiency from the system, steam traps need to be tested properly and regularly. [8] These methods need to be easy to use as traps are often in confined locations and hard to access. The two most common forms of testing are thermograph and ultrasonic. Both can be conducted on site with compact lightweight tools and the results can be analysed immediately. [9] This allows problems to be identified and investigated fully to give a better understanding of the entire system and all its inefficiencies.[10]




Testing Setup

Fig 3-Test setup along with components

| **Sr. No.** | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 |
|---|---|---|---|---|---|---|---|---|---|---|
| **Component** | Compressor | Drain plug | Nipple | Elbow | Barrel pipe | Line cock | Water cock | Tee joint | Steam trap | L-bend |

Table No 2-Discription of the component & their location

## VI. STEAM TRAP TESTING

Following methods are used for testing Thermodynamic steam trap.

**6.1. Hydraulic Testing:** Hydraulic testing method is used to detect manufacturing defects in the steam trap. Leakage between disc cap and body is detected by filling the steam trap by pressurised water. After the testing it is clear that there is no manufacturing defect in our advanced steam trap. [11]

Fig 4-Haydraulic testing setup for thermodynamic steam trap

**6.2. Pneumatic Testing:** Pneumatic testing method is used to test the performance of the steam trap. In this method the test model is connected to a compressor and water is added through the water valve and hence performance is tested as the steam trap removes water from the system. The performance is good than existing system. (Refer fig no 3)[12]

**6.3. Flatness Testing using Optical flat:** An optical flat is usually placed upon a flat surface to be tested. If the surface is clean and reflective enough, rainbow colour bands of interference fringes will form when the test piece is illuminated with white light. However, if a monochromatic light is used to illuminate the work piece, such as helium, low-pressure sodium, or a laser, then a series of dark and light interference fringes will form. [13] These interference fringes determine the flatness of the work piece, relative to the optical flat, to within a fraction of the wavelength of the light. If both surfaces are perfectly the same flatness and parallel to each other, no interference fringes will form. However, there is usually some air trapped between the surfaces. If the surfaces are flat, but a tiny optical wedge of air exists between them, then straight, parallel interference fringes will form, indicating the angle of the wedge (i.e: more, thinner fringes indicate a steeper wedge while fewer but wider fringes indicate less of a wedge).[14,15] The shape of the fringes also indicate the shape of the test surface, because fringes with a bend, a contour, or rings indicate high and low points on the surface, such as rounded edges, hills or valleys, or convex and concave surfaces. Flatness of groove side of the disc and disc seat of the body is tested by using optical flat.



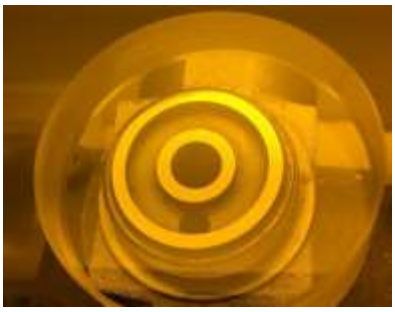


Fig 5- Flatness testing machine and setup, Fig 6- Flatness testing of disc, Fig 7-Flatness testing of body

## VII. CONCLUSION

Improvement in maintenance of thermodynamic steam traps by reducing maintenance time and cost. Improving steam system maintenance frequently results in other benefits, such as long lasting product and reduces labour work. Performance of the manufactured and existing product is unaffected. The cost of the manufactured product is reduced without compromising their performance. One piece body eliminates internal gaskets and leak paths. Simple design of product results in reduced manufacturing cost and time. All stainless steel components provide dependable operation in severe applications.

## VIII. FUTURE SCOPE

Improving steam trap maintenance practices can increase the performance of almost any steam system. Steam systems are found throughout industry and consume a significant portion of the energy used at manufacturing plants.Steam systems are often overlooked as a source of operating cost improvements. However, steam systems are inherently energy intensive, and energy assessments can often find operating and maintenance practices that lead to avoidable energy losses.

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