Performance Analysis Venturi Orifice Steam Traps

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Background

Over the last century, steam traps have developed with various automatic valve arrangements using buckets, floats, thermostatic and thermodynamic valve arrangements, all with moving parts. As with anything mechanical, these traps are prone to failure and may fail:

a) Closed – causing water-logging, corrosion and in some cases water hammer
b) Open – leaking live steam and energy

Additionally, where traps that are failed open discharge into condensate return systems, they cause pressurisation of the condensate lines. This inhibits trap drainage and often reduces heat output and hence productivity.

Over the last decade, a new type of steam trap has gained UK market acceptance in overcoming these problems due its lack of moving components. Like all previous types of orifice trap, the GEM™ Trap is a venturi orifice trap which uses the condensate to hold back steam rather than any valve arrangement. However, unlike previous orifice plate traps, its makers claim that a unique venturi allows it to operate over varying load conditions by use of the flash steam emitting from the condensate within its discharge throats and this principle is described on the manufacturer's website www.gemtrap.com. Thus, it obviates the need for continual testing repair and maintenance of steam traps whilst providing the variable discharge capacities demanded of steam traps serving the variable loads within industrial applications.

Fig. 1: Cut through of mechanical inverted bucket steam trap

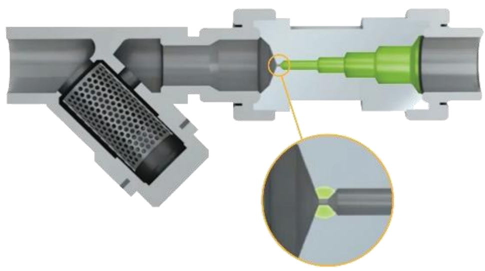


Fig. 2: Cut through of GEM™ Trap

Objective

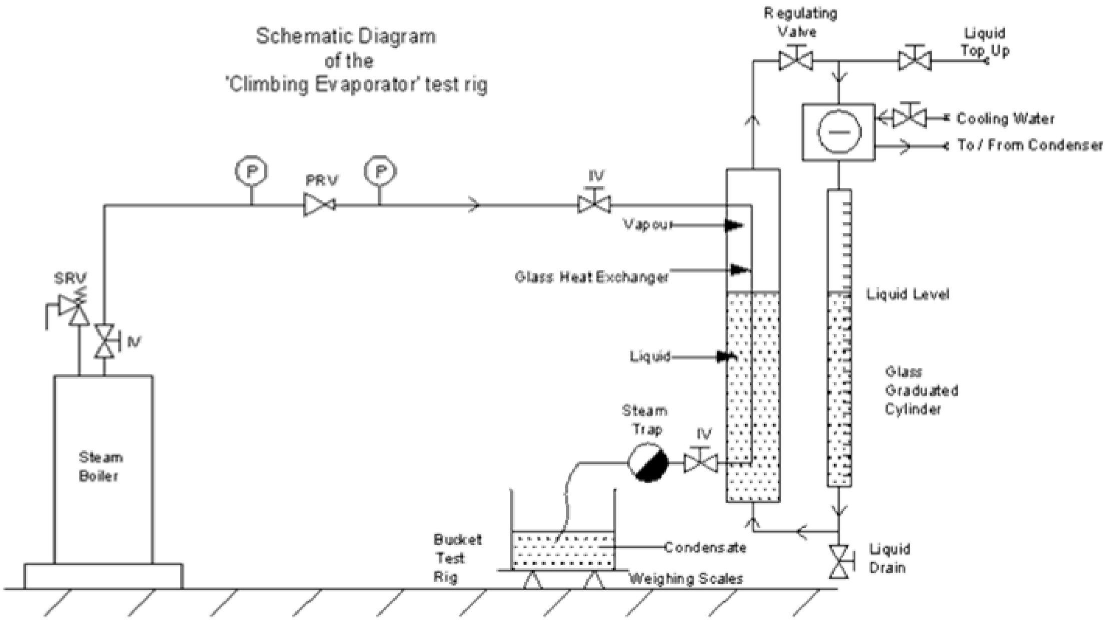
The purpose of this study is to perform efficiency tests over variable loads, according to BS EN 27841: 1991, on this type of venturi orifice trap and compare them with those of a variety of commonly used mechanical traps. For a like for like comparison the mechanical traps tested shall be of new condition but it is noted that their performance in practice diminishes in time as components wear and progressively fail. Steam losses through failed mechanical traps are not the subject of this study.

Method

The ‘climbing film evaporator’ test rig, depicted below, was chosen for the tests as it is constructed from glass and the flow of liquids and gasses may be monitored visually. The rig works like any other heat exchanger, but has the advantage that heat outputs, and hence condensate loads, may be altered by regulating the flow of evaporative liquid on the secondary side of the exchanger. This changes the liquid level and hence heat transfer area of the exchanger without any change in steam pressure.

Therefore, this method fully tests the claims of the orifice trap manufacturer in that arguably the most testing conditions are exerted on their trap – that of full steam pressure with a full range of condensate flows. It is noted that most variable load applications in industry are fitted with control valves and so as the heat loads vary, the steam pressure will be regulated. Thus, at low loads there will be less condensate produced and less steam pressure exerted on the trap. Any steam losses through the orifice trap at low loads, when there is less condensate present to hold back steam, will be negligible compared to those where full steam pressure is present while condensate loads are varied as in our test rig.

Tests were performed for each trap at a constant pressure of 54 Psig and varying flows from ‘no flow’ to 20 kg/hr. Calorimeter or ‘Bucket’ tests were conducted according to the European Standard to measure the live steam loss through traps at five various load conditions expressed as the level of liquid in the evaporative column in the rig.



Results

Below is an example of the results form a range of tests conducted at a fluid level of 20cm within the column:

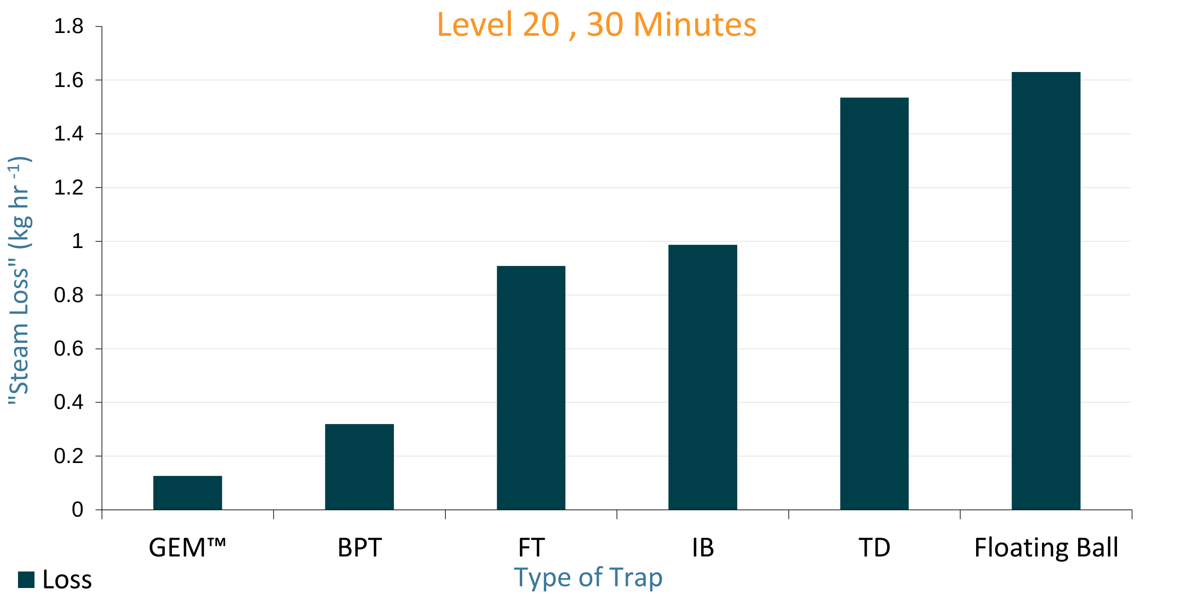


Fig 1. Comparison of live steam losses through different traps at flow level 20 cm under 54 Psig, for 30 minutes

Collating these tests and expressing them in a graph of live steam loss over the range of conditions tested:

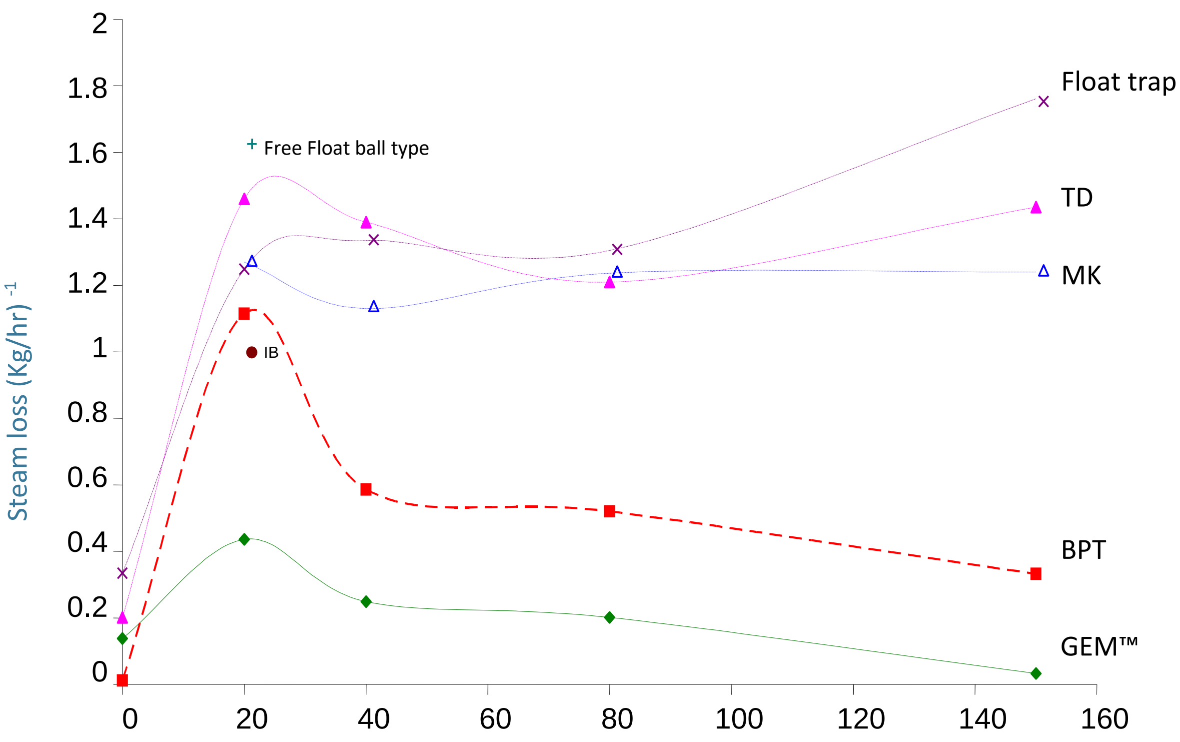


Fig 2. Comparison of live steam losses through different traps at different flow levels under 54 Psig.

These results show that the GEM™ Trap is significantly more efficient over varying loads than all other types of traps. The free float trap (Floating Ball type) and the more conventional float trap are the least efficient with losses averaging over 1.5 kg/hr. The TD thermodynamic and 'MK' thermostatic traps were only slightly more efficient but significantly all these traps were less efficient than the GEM™ at no condensate load. This is especially significant as there is a perception that orifice venture traps are inefficient at low load conditions when there is little condensate present to hold back steam. These results disprove this theory and paradoxically show that it is the mechanical traps that are inefficient at low condensate loads.

The BPT balanced pressure thermostatic was significantly more efficient than the other types of trap at high condensate loads but the GEM™ Trap has easily the greatest efficiencies over varying loads.

Conclusions

From these tests, carried out over varying condensate loads, it is concluded that:

- GEM™ Trap is the most efficient trap over the range of condensate loads
- The GEM™ Trap has a continuous discharge and it was noticed that there was less build-up of condensate within the glass heat exchanger / evaporator than with the TD, thermostatic and inverted bucket traps. The float traps had more continuous discharge characteristics but have a high steam loss compared to all other types of traps
- The GEM™ Trap automatically changes it capacity over varying condensate loads and steam pressures. It was noted that as the pressure was varied it was the GEM™ Trap's, rather than the float trap's, capacity that varied resulting in higher losses at lower pressures.

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