Summary
Of
The

Performance Analysis
Of
Venturi Orifice Steam Traps

A Post Graduate Thesis
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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. These traps all have moving parts which, in time, fail either,

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

Additionally when such traps fail open and discharge into condensate return systems, they cause pressurisation of the condensate lines which inhibits trap drainage and often reduces heat output and hence productivity.

Over the last decade a new type of steam trap with no moving parts has gained UK market acceptance in overcoming these operational problems. As it has no parts to fail or wear out, its use obviates the need for continual trap testing, repair and replacement.

Like all previous types of orifice trap, the ‘GEM Trap’ uses the condensate within its orifice to hold back steam, rather than any valve arrangement. However, unlike previous orifice plate traps, it is claimed that a unique staged venturi allows the trap to operate efficiently over the varying load conditions that predominate in industrial steam systems. The operating principle is to use the flash steam emitting from the condensate as it discharges through the venturi to provide a local back pressure to regulate flow. This principle is described by a demonstration program on the manufacturer’s web site www.gemtrap.com. However the purpose of this analysis is to test this theory by measuring the comparative efficiency of the GEM trap over variable loads.

Objective

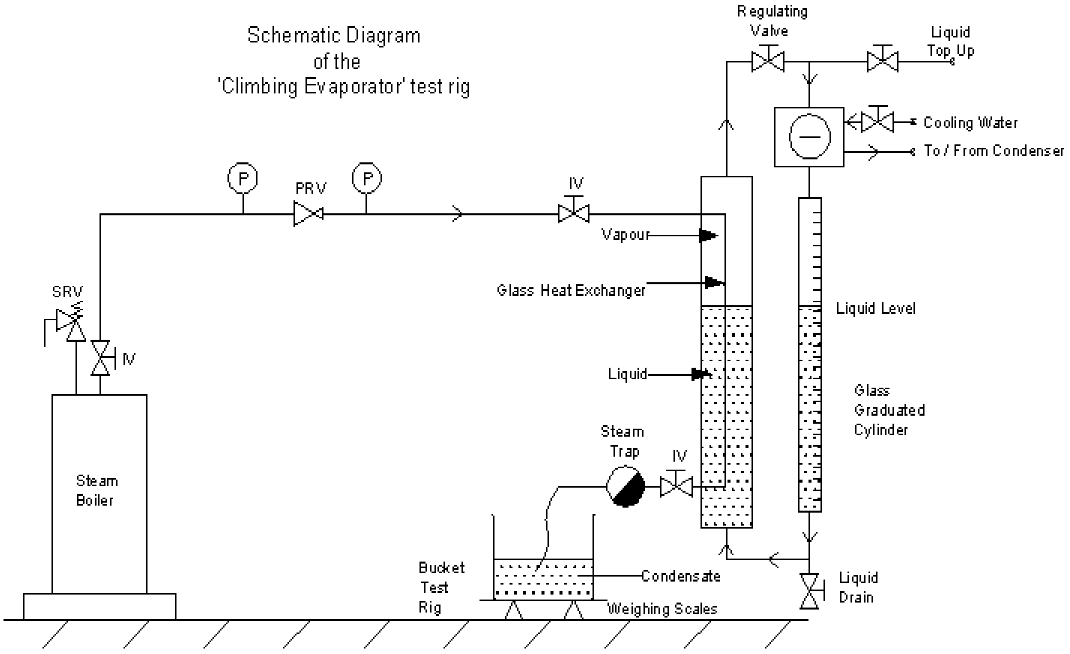
The purpose of this study is to perform efficiency tests over variable loads, according to BS EN 27841 : 1991, on this type of venturi orifice trap and compare them with those of a variety of commonly used mechanical and thermostatic traps. For a like for like comparison the mechanical traps tested shall 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 its glass construction, which allows the flow of steam and condensate to 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.

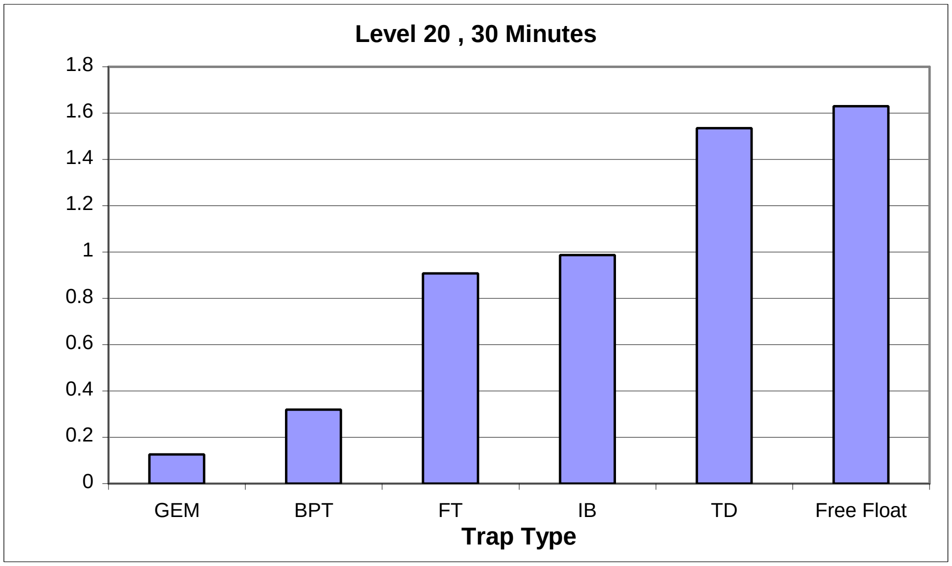
Therefore this method fully tests the claims of the orifice trap manufacturer in that arguably the most testing conditions are exerted on their trap - that of full steam pressure with a full range of condensate flows. However it is noted that most variable load applications in industry are fitted with 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. So 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 the test rig.

Tests were performed for each trap at a constant pressure of 54 psig (3.7bar) and varying flows from ‘no flow’ to 20 kg/hr. ‘Bucket tests’ were conducted according to the European Standard to measure the live steam loss through traps at five various condensate load conditions expressed as the level of liquid in the evaporative column in the rig.


Schematic Diagram
of the
'Climbing Evaporator' test rig

Results

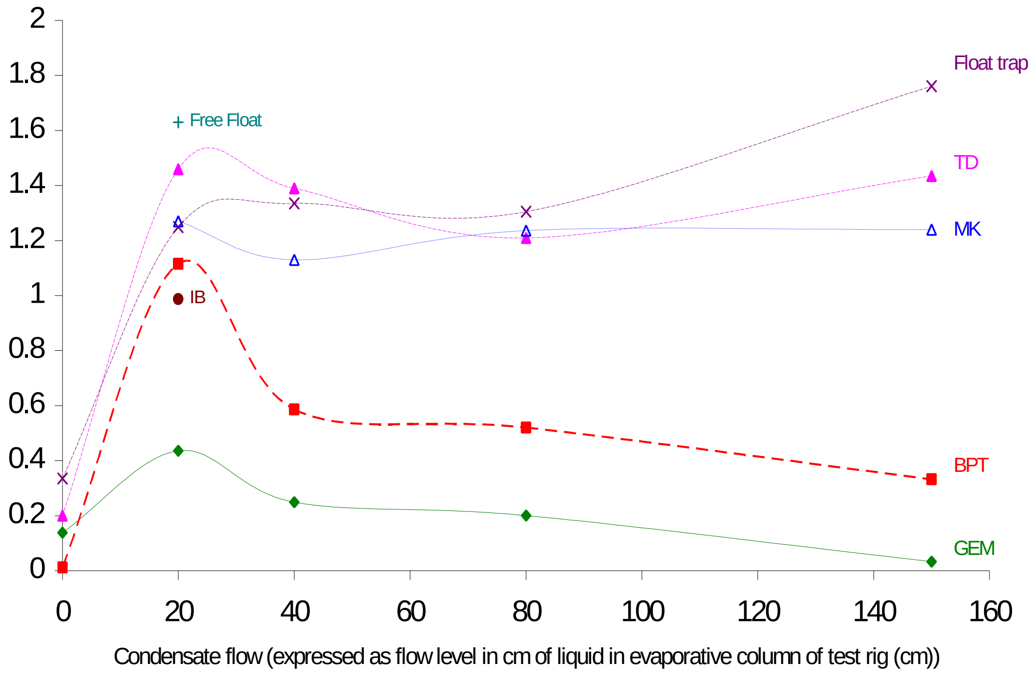
Below is an example of the results form a range of tests conducted at a fluid level of 20cm within the column:



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

These results show the relative efficiencies of each type of trap at a certain condensate flow rate. Tests were then repeated for various other flow rates.

Collating test results and expressing them in a graph of live steam loss over the range of condensate loads:



Comparison of live steam losses through different traps at different flow levels less than 54 Psig.

These results show that the GEM trap is significantly more efficient over varying loads than all other types of traps. The free floating float trap 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 slightly more efficient but all these traps were less efficient than the GEM at no condensate load. This is especially significant due to the 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 conversely show that it is mechanical traps that are inefficient at low condensate loads.

The BPT, or balanced pressure thermostatic trap was significantly more efficient than the other types of mechanical trap at high condensate loads but the GEM trap has significantly greater efficiencies than the BPT over varying loads.

Conclusions

- Measurement of the operational efficiency of both the GEM venturi trap and new conventional traps over varying condensate loads, shows that the GEM trap is more efficient than both mechanical and thermostatic traps in terms of discharging condensate with minimum steam losses.

- The GEM trap proved to have a better efficiency than the float & thermostatic trap in modulating over varying pressures. As the steam pressure decreased the capacity of the GEM trap decreased.

- The GEM trap modulates it capacity over varying condensate loads and steam pressures. Therefore it automatically changes its capacity to adjust to changes in operating conditions, as claimed. However, proper sizing is important to ensure this effective performance.

- The GEM trap has a continuous discharge, so that condensate will not build up in the system causing problems such as corrosion, inefficient heat transfer and water hammering. Other traps, such as the balanced pressure thermostatic, thermodynamic disc and inverted bucket trap operate intermittently, thus allowing the build up of a condensate layer that lowers the effectiveness of the trap. The float and thermostatic trap has a continuous discharge but at a high “steam loss”.