DRIP-POT APPLICATIONS

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Abstract

Drip-pots are basically drains installed on the bottom of pipelines to capture and remove liquid and solid debris pushed along the bottom. In the past, simple 1" to 8" socket drains were often welded on to the bottom of the pipes. Today some pots can exceed 36" in diameter. The cumulative pressure drop across a series of large pots installed in highly turbulent areas can be significant. These larger drip-pots can cost up to $10,000 each to install and in many cases result in no improvement in the removal of liquid and solids. This paper will be a general discussion on the application of drip-pots.

Introduction

Drip-pots, knock-out-pots, drain-pots (all the same) are the most common separation devices installed on geothermal steam piping systems. They utilize the pipeline itself as part of the separator. Its use is invaluable during start-up to prevent condensate build-up, slug flow damage to pipe and equipment, and to prevent the overloading of the final polishing separators located at the power plant.

During normal operations, these devices can act as inexpensive scrubbers to polish the steam prior to entering the turbines. However, the design style, location of the pot, and steam flowing conditions have a significant effect on cost and performance. The removal efficiencies can vary from virtually zero to an excess of 95% removal rate. Although computational techniques can be utilized to define performance, rules of thumb and general statements will be used in this paper to simplify general applications.

Flow Regime

In order for a drip-pot to function properly, gravity and time must cause the liquid and solid fraction to flow along the bottom of the pipe. The defined flow pattern for effective removal can be described as stratified flow. For fully developed flow, the regime can be defined by the pressure, temperature, viscosity, density, surface tension, pipe diameter, mass flow rates and inclination of the pipe. A basic flow map is provided for reference in Figure 1.

The flow regime in steam piping during start-up can quickly change from stratified to slug to annular/mist and disperse (fig. 2, 3, 4 & 5). One of the key purposes of drip-pots use is to prevent a slug flow condition from occurring. Remove enough liquid and a slugging transient cannot adequately form.

Slug damage will occur where a large liquid mass is picked up, accelerated at high vapor rates and impacts onto elbows and equipment. Pipelines can be thrown off supports, anchors and guides torn loose and ruptures can occur. The success of slug flow prevention is to drain bulk fluid from steam pipelines while bringing production wells slowly on line.

The greatest danger of slug flow exists between superficial steam rates of 5'/s to 50'/s range, unless shock is involved. Above 80'/s the danger of slug flow is greatly diminished except on certain incline situations. At higher velocities, the flow profile changes to annular/mist/disperse. Drip-pots are not normally effective in these flow regimes.

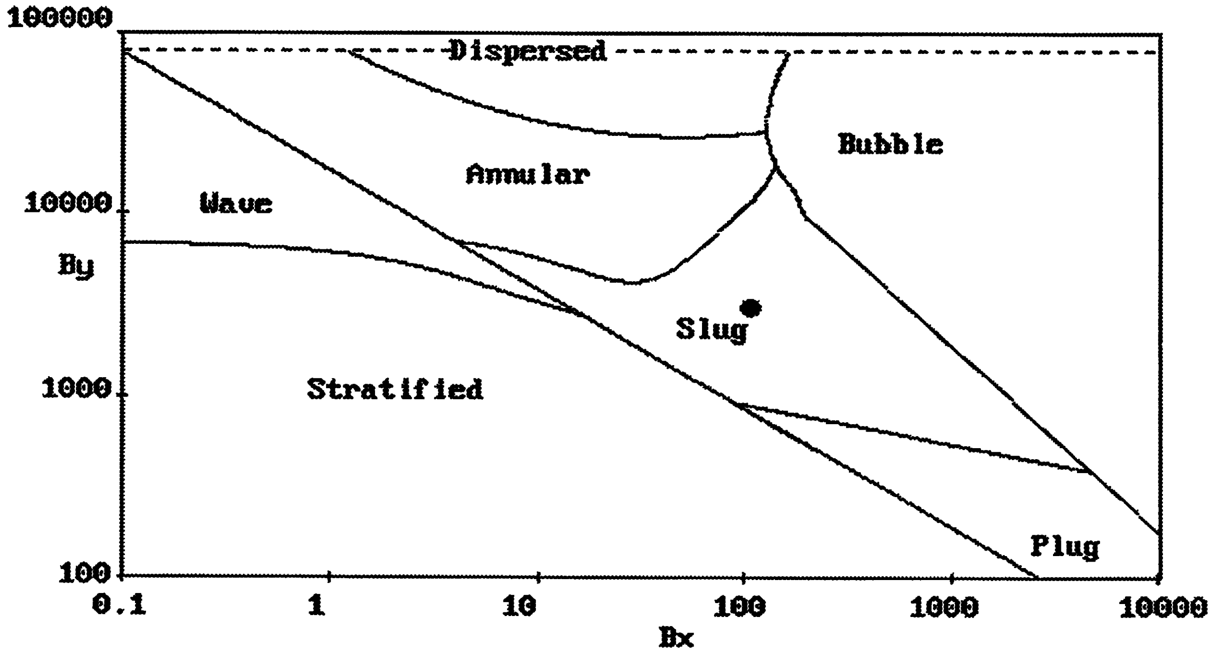

FIGURE 1

IDEAL FLOW CONDITION STRATIFIED FLOW

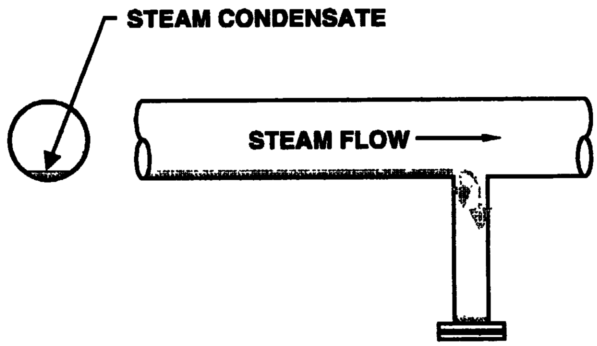

FIGURE 2

SLUG FLOW

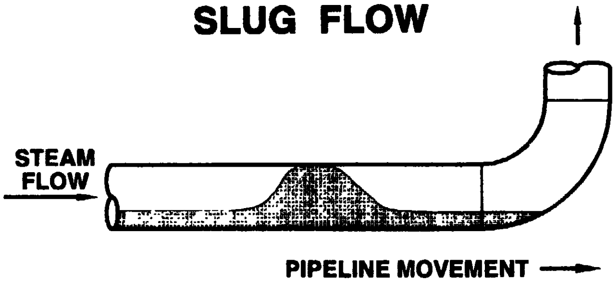

FIGURE 3

HIGHER STEAM RATES ANNULAR / ANNULAR MIST

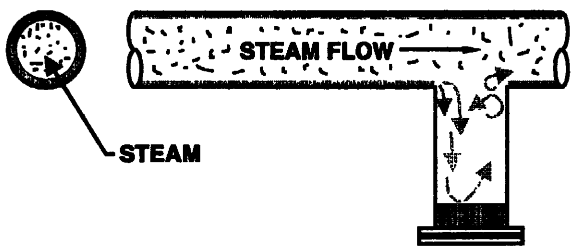

FIGURE 4

HIGHEST RATE DISPERSED FLOW

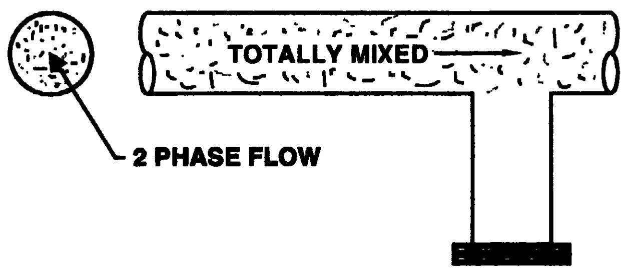

FIGURE 5

Design Styles

There are four basic types:

- 1" - 2" Drains
- 6" - 8" Diameter Pots
- Standard 1/2 Diameter to One Diameter Pots
- Custom Designed High Performance Pots

The standard two inch drain installed on the bottom of the pipe can be used where the operating steam velocity is significantly above 100'/s, super-heated steam or high turbulent conditions exist. This inexpensive option is for start-up use only and not for continuous scrubbing operations.

The 6"- 8" drip-pots are useful for start-up and provide better draining capacity than a 2" stub-in. It is useful in capturing a limited amount of solid debris. They do not function well above 50'/s.

The standard 1/2 pipe diameter and larger drip-pots are virtually inline separators. Their performances are generally excellent at line velocities below 60'/s and poor above 100'/s. The higher the superficial steam velocity, the lower the capacity and removal efficiency. 100 pipe diameters or more of straight pipe is required for optimum performance at higher velocities.

Custom designed drip-pots can offer superior performance over conventional drip-pots. Here system modeling can simulate the boundary layer conditions based on upstream turbulence (elbows, fittings, valves, etc.) straight run of pipe, steam/liquid rates. Inlet line velocities to 200'/s, with 90% liquid removal rates are possible. These special designs are especially useful where low pressure losses, limited straight runs of pipe (as little as 10 diameters) and high liquid removal efficiency are required.

Where To Place Pots

Drip-pots should be installed on all low points along a line and away from elbows, fittings, valves, orifice, annubars, venturi, thermowells, separators and other turbulence that can cause shattering of the liquid from the bottom of the pipe. Performance will be best where a fully established stratified flow profile has developed. Generally, a 100 pipe diameter of straight pipe run is required for optimum performance (fig. 6). Unfortunately, unless expansion bellow type piping designs are used, it is difficult to find this much straight pipe. Fair performance can be obtained with 25 pipe diameters if the line velocities are moderate. Where non ideal conditions exist or optimum performance is required, computer modeling and special designs can significantly reduce the 100 diameters needs for profile development.

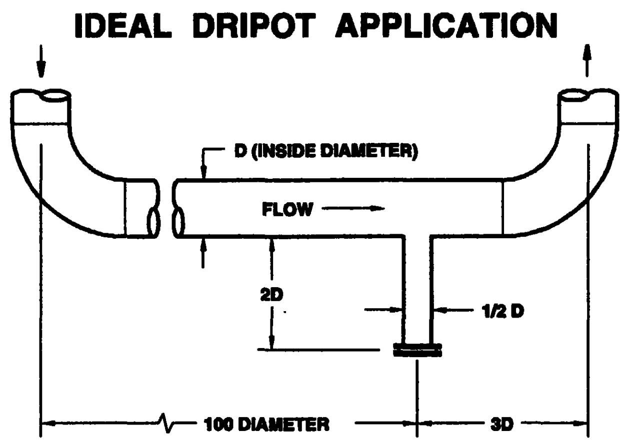

FIGURE 6

Condensate Catching Capacity

Drip-pots can handle large amounts of liquid at low velocities. However as the vapor rates increase, a increase in liquid rate can alter the flow regime from stratified to annular flow to mist. At the higher velocities the fluid tends to jump over the pots and other gas dynamic conditions occur.

General application of drip-pots limit the liquid removal from a fraction of a percentage to several percent of the total mass rate. Applied properly, these inexpensive inline separators can provide good series scrubbing (James).

Drip-pots cannot provide the protection and capacity of wellsite and plant station separators. They are useful in supplementing primary separators and acting as series polishing separators (James).

Efficiency

Liquid removal efficiency varies depending on the design style. As a rule of thumb, standard pots used in line velocities less than 60'/s can obtain efficiencies above 95%, however at line velocity above 100'/s the removal rate can drop below 10%. For moderate performance a 30 diameters straight run is required down-stream of any elbow or fitting. Larger 2/3 diameter pots can be more efficient than 1/2 diameter pots.

The depth of the pot can vary with approximately two steam line pipe diameters being an effective minimum length. Turbulence and standing waves can effect the performance of short pots. Baffles are sometime used to mitigate these effects (Freeston / Lee).

For special design pots, line velocities to 200'/s with 90% liquid removal rates are possible with only 10 diameters of straight pipe run. These instruments have specially designed internals to condition boundary layers, mitigate vortex and standing wave effect.

Pressure Drop:

Pressure drops across drip-pots are generally low but can vary from 2% to 20% of the dynamic head. The larger the pot diameter, the greater the pressure drop. A full diameter pot will have twice the pressure drop of a 2/3 diameter pot, which will have twice the pressure drop of a 1/2 diameter pot (Freeston/Lee). A shallow pot can cause greater pressure drop than deeper ones. Pots installed near down-stream elbows can create large losses in excess of 50% (Jung; fig. 7).

QUESTIONABLE DRIPOT SIZE

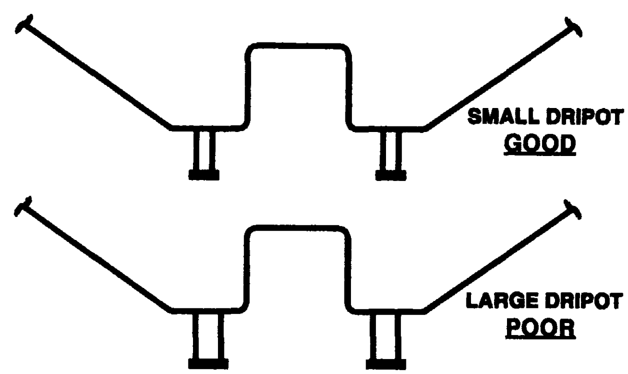

FIGURE 7

Summary

1. Install drains or drip-pots on all low points along steam lines.

2. A stratified flow regime is required for good drip-pot performance. High efficiency can be expected below line velocities of 60'/s, and poor efficiency above 100'/s.

3. Diameters of straight pipe is required for optimum performance. 100 Diameters is required for marginal performance.

4. Custom boundary layer drip-pots are superior to standard pots at high velocities and in undeveloped profiles. Liquid removal efficiency can exceed 90%, at inlet apparatus velocities to 200'/s.

5. Pressure drops across drip-pots are generally low (less than .1 psi). However pots installed near highly turbulent zones can incur high pressure drops (>.5psi).

6. Standard large diameter drip-pots can cost up to $10,000 each to install. In applications where line velocities will exceed 100'/s, super-heat steam conditions or short upstream pipe runs exist, consider lower pressure drop, lower cost 6" - 8" drip-pots.

7. Drip-pots can supplement but cannot replace mainline separators.

Reference

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