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LEAMS
Low Emissions Atmospheric Metering Separator For Drilling and Well Testing

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Key Words

Drilling, environmental, flow-test, separator

Abstract

The LEAMS Project stands for the development of a *Low Emissions, Atmospheric, Metering, Separator* for geothermal drilling and well-testing use. This novel system is designed to be environmentally friendly, intrinsically safe, can be used for air/mud/mist or foam drilling with the ability to meter steam and brine flow while drilling ahead. Currently, no drilling separator can perform all these functions under a single system nor can they perform any one of these functions exceptionally well.

This new system is intended to replace the old Blooie Muffler (cyclone) which is notorious for its low separating efficiency (covering hillsides with drilling debris), instability (blown off location by slugs), inability to meter two-phase while drilling ahead, and difficulty in transporting and moving the separator. The LEAMS is expandable to wells beyond 25MW.

The LEAMS is designed to reduce the solid and liquid pollution by up to 99 percent on large wells. The vented steam will be clean of formation debris, abatement chemicals, and toxic waste. It will have the ability to internally abate hydrogen sulfide gas, have the ability to meter two-phase flow without drilling rig down-time and can be shipped in containerized components and erector set assembled. The design of the system dissipates high-energy slugs, keeping such pieces of equipment from being launched off the location.

Introduction

The geothermal industry uses vertical cyclone separators known as blooie mufflers for noise attenuation and liquid and solid removal during drilling operations. In the past, this has been the only means to remove solids and liquids from geothermal vapor vented to the atmosphere. These devices have incurred high erosion rates, have low separating efficiencies, are marginally effective at reducing noise and are unstable when hit with slugs. It is not uncommon on large wells or transients to cover the mountainside with debris or even eject these vessels off the location. The large sizes of these conventional units create shipping difficulties, reduced mobility on public roads and incur greater cost.

Conventional drilling cyclones are typically “can-type” tanks with a tangential or spiral entry. As the flow exits the blooie line and enters tangentially into the circular tank, a spin is induced forcing the denser material to the vessel wall for gravity drainage. These drilling cyclones are not optimally designed and tend to have rather low separating efficiencies because of very high inlet velocities, re-entrainment, particulate shatter and core channeling. Noise attenuation is marginal as this emission can be directed straight upward from the stack.

For drilling operation, two different cyclones are often used. One smaller unit for air/mud drilling and a larger flow-test unit. Rig stand-by time is involved to change over systems. When these cyclones are exceeded in capacity or encountering transients, it is during these occasions that hot mud, solid or liquid formation fluids. Or abatement chemicals can be blown throughout the location or the cyclone itself is blown from its supports and off the location. These episodes may be entertaining from an anecdotal point of view, but are clearly undesirable to all parties involved.

LEAMS Advantage

The LEAMS is designed to address the following concerns:

- RIG STANDBY – Reduce the time and need to convert over to flow-testing systems (5 Days +/-). One LEAMS can replace two cyclone style used for air and flow testing.
- PORTABILITY - Modular units designed to fit into conventional 7.5' x 39' shipping containers. Components can be assembled on location. Current 12' - 16' diameter cyclone units are very expensive and difficult to ship and transport to the field.
- FLEXIBILITY - This basic design can be used in dry steam as well as hot water flash systems without modification.
- MULTIPURPOSE - LEAMS can be used for drilling, well-testing and production.
- SAFETY - Reduces the possibility of blowing a hole through the separator or launching the device off the location from transients.
- HIGH EFFICIENCY - Computer simulation studies show that the particle size catching ability of the conventional blooie muffler (drilling separator) is only 15% that of conventional high performance cyclones.
- PLANT TRIP - Power plants have been being tripped off line from drilling and venting operations. This is caused by carry-over from drilling separators send large amounts of highly conductive brine and other impurities through high

voltage power lines and equipment. Clean steam significantly reduces this problem.

- ENVIRONMENTAL – Reduces solid/liquid carry-over emissions by up to 99 percent.
  - See LEAMS, Fig. 1

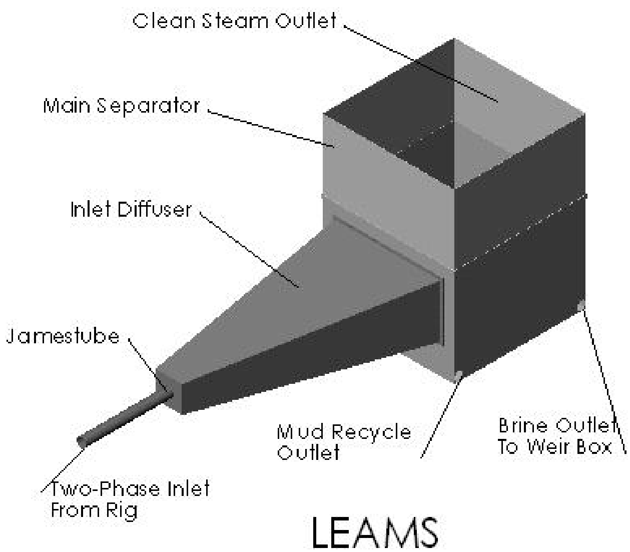

Fig. 1

Design Concept

The basic LEAMS can be broken down into three sections:

1. Inlet Diffuser – Jamestube, Diffuser
2. Lower Body – Flow Diverter, Mud and Brine Handling
3. Upper Body – Primary Separator, Secondary H_2S Abatement, Mist Eliminator

The "Inlet Diffuser Section" is a transition piece to disengage the high velocity flow before entering the vessel body. With the Jamestube insert, the velocity will be sonic with very high erosion and impulse damage potential. The flow will be allowed to expand and decelerate prior to entering a diffuser assembly. This diverter will section off and force equalization of the flow distribution. This will reduce the high gradients into the central portion of the body. For conventional mud drilling operation, the diverters will be non functional whereas the mud will drain down the diffuser assembly into a mud catch basin in the lower body for recycling. See Fig. 2.

The "Lower Body Section" is where the distributed flow enters for processing. Under mud drilling operations, the mud and cuttings can drain down into a collection basin at the front part of the body. The mud is pumped back and recycled but the added weight from the fluid helps to stabilize the vessel in the event of transients. When production is encountered, the bulk brine will gravitate toward the bottom and is drained into a weir box for measurement. The steam and entrained brine will impinge on upflow diverters and equalizing section.

The "Upper Body Section" is the separator section. Two sets of separator sections are installed plus an optional scrubber assembly. As the steam flows upward with the entrained impurities it first strikes roughing impingement plates. This section will help equalize and remove particles below 100 microns in size. An optional scrubber section can be included for H_2S removal or demister washing. Following the primary separator, high efficiency low loss demisters could remove particulate down to below 40 microns. These are particulates about the diameter of a hair. Note many cyclones cannot catch particles smaller than 1000 microns.

The bulk of the LEAMS can be fabricated from mild steel with alloying on critical areas. The demister section can be made of corrosion and scale resistant high temperature plastic. The pressure drop across the upper body section can be less than a centimeter of water column.

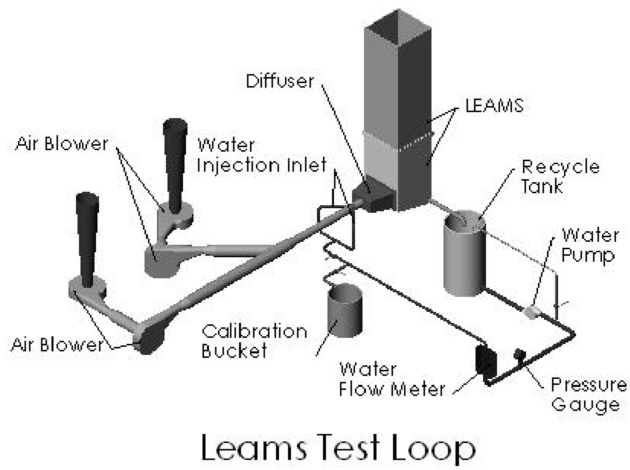

Fig. 2

Complexities

- ♦ Inlet to LEAMS to 1,500 Feet Per Second
- ♦ Large Capacity ~ Up to 375KPHS/1000KPHB
- ♦ First 15 Feet Blast Distance Negligible Velocity Decrease
- ♦ Conventional Design For Diffuser >> 100 Feet Required
- ♦ LEAMS Diffuser 25 Feet.
- ♦ Fine Particle Size
- ♦ Equalize Flow Distribution
- ♦ Erosion Control & Low Cost Structure
- ♦ Coalescent & High Separation Efficiency

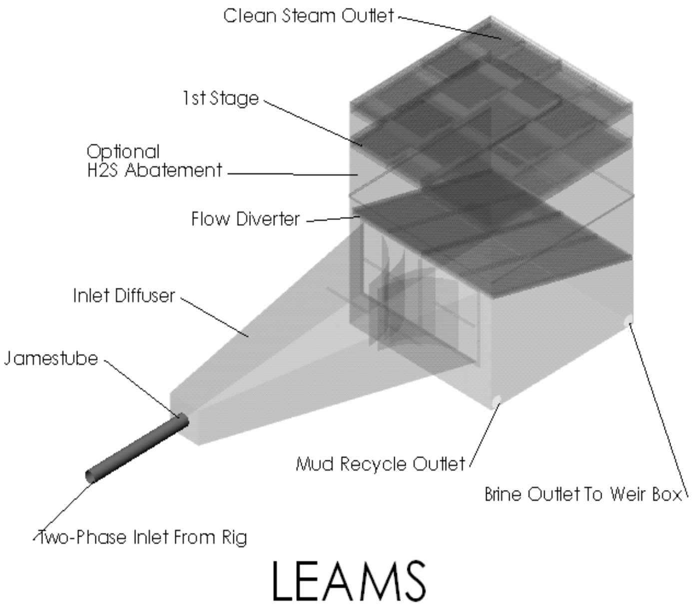

Fig. 3

Experiment

An air/water system was designed and fabricated to test the various configurations of the LEAMS internals. Blowers were installed, spray nozzles, re-circulating pumps, air and water flow meters, temperature and pressure measurements. The basic line size inlet was 50mm (2 inch). Air velocity varied to roughly 100 m/s. The water injection rate was varied to 3500 kg/hr. See Fig 3.

The LEAMS models were made primarily of Plexiglas so that visual observations could be made. Carry-over amounts were detected by visual and defraction techniques. At any specific blower setting, the water rate was increased to observe the flow distribution and effectiveness of various components. It was not practical to subject the model to 500 m/s vapor flow as such the scale models used similitude to shorten the nozzle to apply a lower velocity near the diffuser vanes. The following sections were investigated:

1. Numerous low loss flow-distributing configurations were tried. As can be seen on Fig 2, the turning vanes are to help equalize the high velocity flow prior to entering the vessel body. Without this the flow could channel, short-circuit and blow a hole through the LEAMS.

2. Various vertical deflectors were installed to turn and equalize the flow distribution upward. This change in direction is essential for good secondary separation.

3. Following the vertical flow diverters are the 1st Stage roughing separators. These fabricated elements performed very well and allowed very little mist to escape.

4. A final demister was installed following the 1st Stage Units. These scale resistant demisters are to ensure the highest exit steam quality from the LEAMS discharge.

Fabrication

AutoCAD drawings were prepared and provided to Kern Steel for fabrication. The diffuser section is 7.7 meters long; the base is 4.6 meters x 4.6 meters and the height is 6.2 meters. The bulk of the material is mild steel.

Field Testing

Upon completion, the LEAMS was transported to the COSO Geothermal Field. A side by side comparison between the 12 foot diameter site cyclone and the LEAMS utilizing the second largest well in the field was conducted by Sandia National Laboratory. Preliminary results demonstrated high carry-over with the cyclone from 15% to 100% opening. The LEAMS performed very well eliminating for all practical purposes all carry-over from 0 - 100%.

Environmental & Safety

Safety awareness is becoming increasingly important. Although no casualties have been reported from cyclones being launched off the location resulting from flow transients, the event does occur with periodic regularity and may cause a disastrous incident in the future. These vessels are from two to five meters in diameter and up to 12 meters high. They contain massive amounts of steel in and around them. To tip one over, blow holes through one, or blast one off a location requires considerable energy. The LEAMS will hopefully mitigate these impulse induce damages, especially on large wells.

Environmental concerns over ejected drilling fluid, debris and abatement chemicals over the location and hillside are rather undesirable events. However, conventional cyclones blooie mufflers are notorious poor performers and often result in such incidents, especially during transient conditions. Small cyclones can catch smaller particles and large cyclones require larger particles for effectiveness. But large cyclones have a difficult time catching small particles. Modeling has shown that conventional drilling separator efficiency is less than 15 percent of an optimum design.

Typical geothermal emissions are entrained impurities in the steam fraction. These include dissolved solids, solids, and liquids. Some of these impurities are toxic and harmful to the environment and will increase corrosion and degradation of facilities. The harmful impurities can be carried down wind and cause more widespread impact to the surrounding area. These chemical components can be washed into the watershed contaminating the surrounding riparian and aquatic environments.

Conclusions

The LEAMS design provides a compact, modular, multipurpose muffler and separator that can decrease maintenance, lower cost, abate carry-over (reducing harmful emissions into the surrounding environment), improve mobility, and improve safety. The new design is multipurpose and is intended for use in geothermal drilling, well flow testing, and production.

The LEAMS is a high performance drilling and atmospheric well-test separator. It was designed for environmentally sensitive areas where carry-over emissions from geothermal drilling activities are unacceptable. The device is destined for the Glass Mountain Project in Northern California.

The LEAMS can embrace a number of benefits.

- Reduced Rig Standby Time (5 Days +/-)
- Metering while Drilling Ahead Capability
- Portability (Components)
- Wet or Dry Steam Wells (0% to 100% + SH)
- Multipurpose Drilling/Well-Test/Production
- Safety (Stability)
- High Capacity (2x+ Greater than Cyclone)
- High Efficiency (up to 99% Improvement)
- Low Pressure Loss (Plug Resistant)
- Mitigate Plant Trip (Conductive Steam Plume)
- Environmentally Friendly (Happy Regulators)

An update on field-testing will be presented, as information becomes available.

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