

## Steam Pressure Filtration for the treatment of limey soils contaminated with aliphatic hydrocarbons

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**Abstract:** Laboratory-scale experiments have been carried out to investigate the possibility of remediating soils contaminated with aliphatic hydrocarbons with the help of Steam Pressure Filtration. Two artificial calcareous model soils of different grain size distribution (Füller Gral and Omyacarb 40 Al) have been contaminated with dodecane, isooctane and isopropanole and then subjected to Steam Pressure Filtration. The laboratory tests showed that even contaminants with high boiling point like dodecane, can be expelled from the model soil with the help of steam. The contaminant concentration can be reduced to 0,4% (isopropanole), 0,1% (isooctane) and 1,5% (dodecane) of initial concentration after 300 s subjected to pressurized water vapor. This steam flows through the porous media of some centimeter thickness. The containment is reduced in the soil samples due to drying effects, dragging forces and changes in the wetting. Additionally, scale-up tests for continuous and discontinuous filter systems (vacuum and pressure filters) have been made. The use of Steam Pressure Filtration offers different advantages: first, soil treated with this method remains biologically active, second, there are no toxic by-products which have to be treated and third, the water necessary for the process can be reused for dispensing the soil matrix.

Soils contaminated with aliphatic hydrocarbons are a widespread problem. There is a variety of technologies available for the remediation of such soils. The idea of Steam Pressure Filtration (SPF) dates back to a German patent by Baganz (1930). Both fluid viscosity and surface tension in the filter cake should be decreased to effect better dewatering of the filter cake. Laboratory tests showed the possibility of removing solvent solutions from soil with the help of SPF (Schabel 1999). Laboratory-scale experiments have been conducted to investigate the possibility of remediating soils with dodecane, isooctane and isopropanole as model substances with the help of SPF. Two artificial calcareous model soils of different grain size distribution, Omyacarb 40 Al and Füller Gral have been selected by as solid substances. Particle size distributions have been determined by a Sympatec HELOS (H9236) SUCCELL particle sizer. Particle size distributions correspond to a silty to sandy soil. Porosity  $\varepsilon$  and density  $\rho$  amount to  $\varepsilon = 0,44$  and  $\rho = 2,7 \text{ g/cm}^3$  for both materials. For the experiments dodecane (boiling point 216 °C), isooctane (boiling point 99 °C) and as solvent isopropanol is used. The testing apparatus consists of a steam pressure suction filter in which temperature can be controlled by an oil heating. The filter cake unit and a water-cooled condenser are located at the lower end of the apparatus (Krupp 2000).

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Temperature can be measured with the help of Ni-Cr-Ni thermoelements which can be placed in different filter cake heights. To determine the water content of the filter cake, a freezing unit has been used. The concentration of dodecane, isooctane and isopropanole has been measured with the help of a Hewlett Packard GC HP 6890 MSD 5973 gas chromatograph.

Lab tests with one, two and three solvents have been conducted. A typical temperature development of tests with dodecane, isooctane, isopropanole and Omyacarb 40 shows that compared to tests with just one solvent the steam breakthrough is observed at much larger times. Average time for steam breakthrough measured from 12 tests was 39 s in contrary to the system Omyacarb 40 and dodecane-isooctane where steam breakthrough time was 8 s. Filter cake structure can be compared to a water-saturated system. After exposing the system to steam for 300 s only 0,1 % of isooctane, 0,4 % of isopropanole and 1,5 % of dodecane remain in the filter cake (Figure 1).

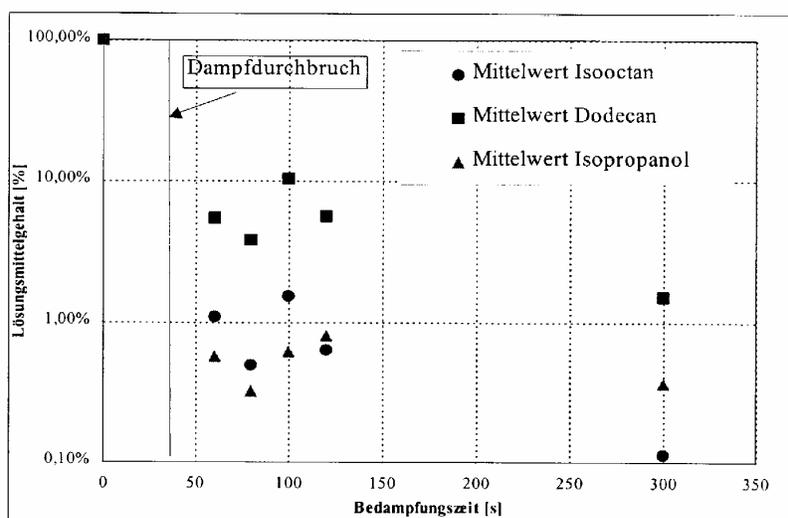


Figure 1 – Solvent removal during steam pressure filtration of the system dodecane-isooctane-isopropanole / Omyacarb 40 Al (filter cake height  $h_k = 17\text{mm}$ ;  $\Delta p = 2\text{ bar}$ ).

Decrease of solvent concentration after steam breakthrough is caused by the subsequent steam drying. Solvent decrease from calcareous Füller Gral is faster than from Omyacarb 40 Al as Füller Gral is a much coarser material and forms a much more porous filter cake. Isopropanole in the mixture causes an enhanced wetting of the filter cake.

The lab tests showed that remediation of contaminated filter cakes is possible with the help of steam pressure filtration. Theoretically, it can be applied to continuous and discontinuous vacuum and pressure filters. Yet the use of steam requires additional construction elements e.g. a steam hood (Gerl 1998). In this work, a scale-up of lab tests on drum filters is investigated. These filters work continuously and are used in a wide variety of applications (Nicolaou 1991). Filter areas range from 0,1 to 180  $\text{m}^2$ . All materials used must endure mechanical and thermal stress. The process of SPF in a drum filter is shown in Figure 2.

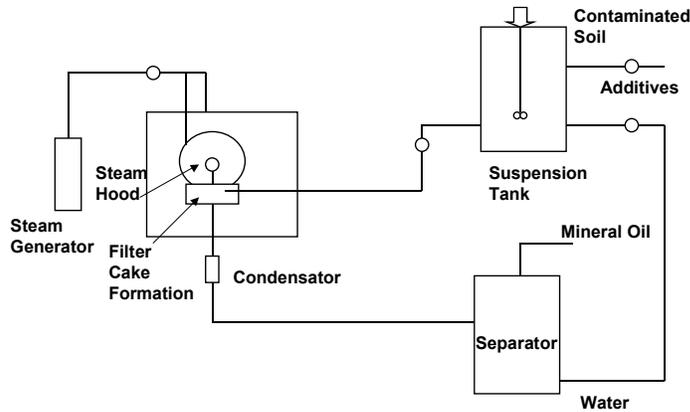


Figure 2 – Steam Pressure Filtration in drum filters

The contaminated soil is fed into a suspension tank in which it is mixed with water and additives to form a soil suspension. This suspension is pumped into the drum filter. Filter cake formation is achieved by applying a pressure gradient onto the drum filter. The filter cake then emerges from suspension. Steam is produced in a steam generator and led into the steam hood. After decontamination of the filter cake it can be removed from the filter which is cleaned. Then the process can be repeated with new suspension.

This method offers several advantages. The soil remains biologically active after treatment and can be reused on-site. The treatment unit can also be used on-site. Remediation times remain relatively short compared to biological remediation. There are no toxic by-products which have to be treated and the water necessary for the process can be reused for dispensing the soil matrix.

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