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Thermal Treatment of Highly Concentrated Landfill Leachate

Introduction

Leachate in landfills is a serious environmental problem. It is common to treat landfill leachate (LL) by reverse osmosis (RO). This technology is suitable for the recovery of water, but it produces a highly contaminated residual liquid, which in this study will be called landfill leachate concentrate (LLC), which must be disposed of safely. The common practice of elimination was to return the LLC to the landfill. The consequence of this procedure is a continuous increment in the conductivity of the leachate with a negative impact in the efficiency of the reverse osmosis plant.

This study proposes an alternative to reduce the volume of leachate using an energy-self-sufficient leachate evaporation system using a Multi-stage flash (MSF) evaporation and Landfill gas (LFG) as energy source for a steam boiler. MSF is specially suitable to treat LLC mainly because in MSF the heat transfer happens in the heat exchanger while LLC is still in liquid form but the evaporation takes place in the expansion chamber. This sequence minimizes the amount of scaling that can occur in the pipes and heat exchangers which is an important problem to avoid when evaporating leachate.

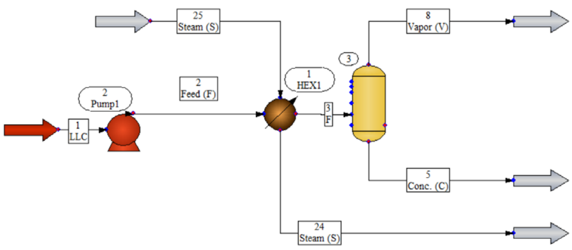

Fig. 1: Diagram of single step of leachate flash evaporation used by the simulation software

Procedure

The design done in this study includes landfill and leachate data assessment, evaluation of different operation scenarios, development of a standardized case model of leachate and landfill gas to be used in a process simulator, creation of a piping and instrumentation diagram (P&ID) along with control and equipment concept and finally an economical assessment of the proposed system. In a first step, research in the theory of design and operation of evaporation technology was necessary. In a second step, thermodynamic and process related models were established to support the development of the design. The software Chemcad 7 and PinCH 3.2 were used to evaluate and simulate LFG preconditioning, multiple steps flash evaporation and an optimization of the heat exchanger network.

Results

It has been demonstrated that for a standard mass flow of 0.5 kg/s of LLC, expected in a large size landfill, a MSF system of 5 steps is the optimal for reducing the volume of waste to be disposed by incineration. Such a system will reduce the inlet volume of LLC to 50 %. The total operation cost varies strongly with the price considered for the hot utility. When considering that the price of landfill gas is half of the price of natural gas, the total operation cost is calculated to be CHF 264’000/a resulting in net potential annual savings up to CHF 379’000. A constant LFG volume flow of 300 Nm^3/h, a steam boiler of 1 MW at 12 bar, and 22 KW of electrical power for pumping and gas cooling in summer are required. The total investment required is calculated at CHF 663’700. As a result, an amortization period below 2 years, based on savings produced due to less disposal of sludge by incineration, can only be reached with incineration cost above 78 CHF/ton. These results are only valid in case that the landfill already has the infrastructure to collect LFG and LL and to burn the excess of gas in an existing flare.

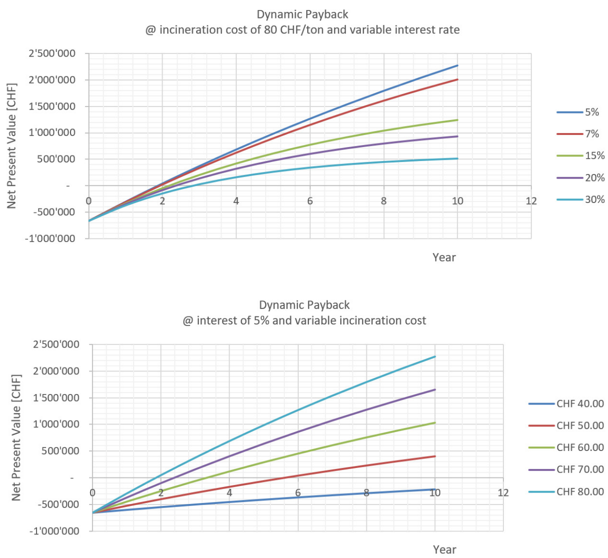

Fig. 2: Dynamic payback of MSF system with variable incineration cost of sludge and variable interest rate