Clean Soil Process Technology for Remediation of Manufactured Gas Plant Sites

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The Alberta Research Council (ARC) and the United States Electric Power Research Institute (EPRI) have developed the Clean Soil Process (CSP) technology for clean-up of soils originating from a variety of contaminated sites.

Thermo Design Engineering Ltd. (TDE), a Canadian company, has acquired worldwide license for the CSP and has manufactured a 'simplified' version of a commercial size mobile CSP plant (~200 tonnes per day) that is currently being demonstrated in New York state, on a MGP site owned by New York State Electric and Gas Corporation (NYSEG). Some of the results of technical and economic evaluations of the demonstration of the 'Simplified' CSP will be presented in this paper.

INTRODUCTION

The characteristic feature of CSP is utilization of organic carbonaceous solids (e.g. coal) as contaminant adsorbents. This feature makes the CSP particularly useful for treating soils contaminated by manufactured gas plants (MGP).

CLEAN SOIL PROCESS PRINCIPLES

The CSP is based on the principle of solid-to-solid abrasive mass transfer. Ground coal and water are added to the contaminated soil and the resulting slurry is tumbled intensively. As a result of shear action, the soil lumps are disintegrated

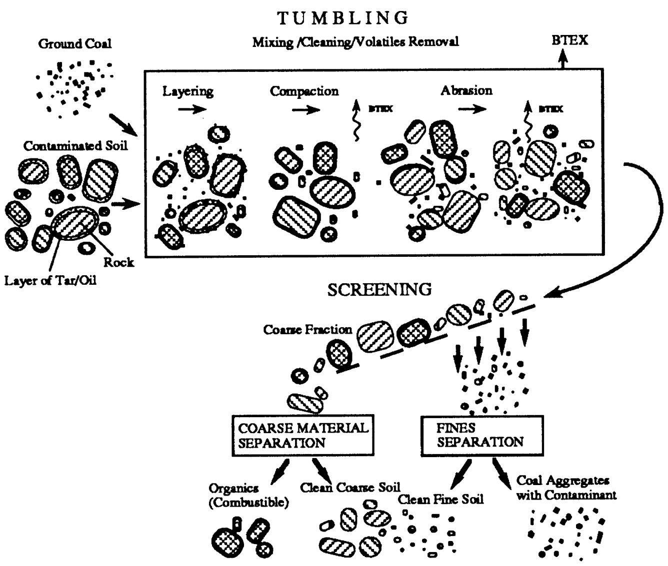

Figure 1. The abrasion mass transfer mechanism of clean-up in the ARC/EPRI clean soil process

thus liberating interlocked particles and contaminants from the soil matrix. The hydrocarbon contaminants in the soil act as the bridging liquid between the particles of coal which is usually used as the contaminant adsorbent. The cleaning process proceeds in phases and involves layering, compaction, abrasion, aggregation and separation as shown in Figure 1.

In phase one of the process the hydrocarbon contaminants (tars, oils) adhering to mineral surfaces are covered by a layer of coal fines. With an increasing number of coal particles penetrating the contaminant, the coal layer thickens and is compacted into a hard shell. When the contaminant becomes saturated with coal particles, the strength of the formed shell reaches its maximum (Hopper 1989). The cohesive forces between coal particles in the shell are usually much stronger than the adhesive forces between the shell and the mineral matter surface. In the next phase due to abrasion, the shell is peeled off from the mineral matter particles. The abrasive mass transfer mechanism occurs primarily as a result of high affinity of the hydrocarbon contaminants to coal and low affinity to mineral matter.

The CSP technology generates well defined streams of homogeneous products like coarse inorganic solids, coarse organic solids, fine clean soil, tarry fines (middlings) and froth (coal coated with contaminants). The management of each product stream depends upon its quality and may include on-site redisposition of clean soil, post-treatment, burning the combustible product in a power plant or permitted facilities, etc.

EXPERIMENTAL

Preliminary laboratory scale tests were performed using a 2-litre tumbler with 200-300 g soil sample and a Denver flotation cell. Some of the batch scale tests were also carried out in a 20-litre tumbler using 3 kg soil samples.

In batch experiments the soil sample and ground coal were slurried with water at solids concentration of about 60% and tumbled at a temperature range of 75–85^{o}C for 10–30 minutes. On completion of tumbling, the sample was removed from the tumbler and separated into two streams by screening. The stream with particle size over 1 mm was separated further into organic and inorganic fractions by gravity separation. The second stream (minus 1 mm) was processed in the mixer and flotation cell and separated into three products; clean fine soil, coal froth and middlings.

Continuous tests were carried out in a 250 kg/hr plant described elsewhere (Ignasiak *et al.* 1991). The objectives for the pilot plant operations were to determine the technical feasibility and performance of the soil clean-up process in a continuous system, and to obtain data required for process scale-up. In a typical pilot plant test, the soil (freed of +50 mm particles) was fed from a hopper by screw feeder into a tumbler where it was mixed with coal slurry generated by a wet coal grinding system. The coal slurry solids concentration was about 50%, and the top size of the coal particles was 0.6 mm. The tumbling was carried out at temperature about 80^{o}C; the residence time was 10–30 min. and the material exiting the tumbler was screened at 1 mm. The +1 mm solids were processed further by jigging which resulted in two streams – clean inorganic solids and contaminated organic solids. The –1mm soil slurry containing microagglomerates was pumped to a high shear mixer to which a collector was added to modify the slurry and promote the growth of coal microagglomerates. The slurry was diluted to about 10% solids concentration, and separated in a flotation cell into clean fine soil, coal microagglomerates and a stream of middlings containing soil particles of size less than 90 µm.

DISCUSSION

The effect of several process parameters on the performance of the CSP process was investigated (Ignasiak *et al.* 1991).

Preliminary studies revealed that residence time, intensity of agitation, slurry temperature, solids concentration and tar/coal (T/C) ratio had considerable effect on process performance. It was established that for MGP samples the temperature and tar/coal ratio were the key processing parameters.

The T/C ratio had a profound effect on the cleanliness of the product. In one experiment with MGP soil the T/C ratio was initially set at 0.13 followed by an increase to 0.28 in the second period. In the third period, coal feeding to the plant was stopped altogether and conventional soil washing (without coal present) was simulated. It appeared that the amount of tar retained in the ‘clean product’ increased dramatically with an increase in the T/C ratio. To achieve satisfactory cleanup the T/C ratio has to be maintained below 0.18. This value is determined by the sorption capacity of coal and is consistent with previous findings (Szymocha *et al.* 1989).

Most of the MGP contaminated soil samples contained large quantities of organic carbonaceous solids (mainly coke) and those solids exhibited considerable affinity toward the tars present in MGP soils. A concept was developed to utilize these solids instead of coal, for adsorption of tars. It appeared that the cleaning efficiency with the coke recovered from the soil was equally as good as with the coal that had to be brought to the processing site. The residual tar content in the middlings is usually high and this results from strong attraction between the contaminants and the fines in the middlings. These fines do not respond readily to cleaning; instead of cleaning the fines it is preferable to combine them with the stream of microagglomerates and use as solid fuel. This solid fuel generated in the CSP process passes the TCLP test and calorific value requirements and is suitable for combustion in conventional coal fired boilers.

CONCLUSIONS

The Clean Soil Process appears to be very effective for treatment of extremely heterogeneous soils contaminated with tars. It performs very well with soils containing significantly more than 1% tar which, for most remediation technologies (bioremediation, thermal desorption), is at the borderline in terms of their effectiveness. It is dramatically less expensive than incineration. The demand for coal in this process can be significantly reduced by separation and utilization of the organic carbonaceous solids usually present in MGP soils. The coal agglomerates containing the polycyclic aromatic hydrocarbons (PAHs) removed from the MGP soils during the processing can be safely combusted in conventional coal-fired power plants.

The process as described above is comparable to soil washing technologies but uses coal instead of surfactants/reagents to facilitate the clean-up. The CSP can be successfully applied to, and meet the cleanliness criteria for, a variety of contaminated soils. For particularly difficult soils, the CSP can be integrated with thermal desorption; this integration allows the most difficult MGP soils to be cleaned to below 100 ppm of total organics and below 3 ppm of total PAHs. Better results can be obtained for non-MGP soils.

The prototype of the CSP plant described in this paper is being demonstrated at a commercial scale (10 t/h) in the State of New York, USA. Subject to results of this demonstration, the integrated CSP (ICSP) will be demonstrated, most likely in Canada, in 1996/97.

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