DRYING FUELS WITH THE CARVER-GREENFIELD PROCESS

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INTRODUCTION

Over 80 plants utilizing the Carver-Greenfield (C-G) Process ® have been licensed worldwide during the past 30 years to dry and convert a wide variety of sludges and other wastes into valuable products, such as fuel, animal feed, and fertilizer. Many of these plants generate energy from such wide-ranging feedstocks as sewage sludge, industrial bio-sludge, wool scouring waste, wood pulp mill sludge, chocolate processing waste, brewery sludge, and dye waste. Table I summarizes those C-G Process™ applications in which some or all of the dried wastes are used as fuels.

PROCESS DESCRIPTION

The patented C-G Process uses the innovative approach of dispersing the waste in a solvent and evaporating all the water out of the suspended solids. A simplified process flow diagram of the C-G Process is shown in Figure 1. The waste is mixed with a solvent to form a slurry containing about 5 lbs solvent/lb solids. The solvent properties can be optimized for the particular application. In cases where the dried solids are to be used as a fuel, a petroleum oil is typically used as the solvent. The waste/solvent slurry is circulated through an energy-efficient evaporator system to evaporate virtually all of the water from the solids. Water levels below 5 percent are typically achieved. Either multi-effect evaporation or mechanical vapor recompression is used to achieve very low energy requirements, in the range of 300 to 500 BTUs per pound of water evaporated, versus over 2000 BTUs per pound for conventional drying processes. The solvent fluidizes the mix and creates a low slurry viscosity, thereby ensuring high heat transfer coefficients and minimal scaling/fouling of the system as the water is evaporated. While evaporation of the water is going on, the solvent extracts oil-soluble contaminants from the waste as well. Since the slurry is raised to over 250°F during processing, any pathogens or other micro-organisms present in the waste are destroyed, thereby avoiding problems with product handling and storage.

After evaporating the water, the slurry is fed to a centrifuge to separate the bulk of the solvent from the dried solids. The residual solvent is removed from the centrifuge cake by "hydroextraction", a desolventizing step involving evaporation and gas stripping. Essentially all of the solvent is recovered and reused in the process. Extracted solvent-soluble compounds can be recovered by distilling the solvent and burned as a fuel separately from the solids.

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Through commercial experience and continuing research, a simpler, less costly and highly reliable version of the C-G Process has been developed. The new process configuration eliminates the more complex equipment used in earlier plants, such as vacuum hydroextraction and slurry-to-slurry heat exchangers. Feedstocks with widely varying compositions can be handled easily, without the need for recycling dry solids.

SLUDGE DRYING

The drying of municipal sewage sludge is an important application of the C-G Process. As shown in Table I, the City of Los Angeles, the County of Los Angeles, and the City of Tokyo have all recently built C-G Process facilities to dry sludge prior to incineration for the generation of steam or electricity. Sewage sludge typically has an energy content of 6,500 BTU per pound of dry solids, although the moisture content has a major impact on the availability of the energy. As shown in Figure 2, drying sewage sludge completely creates a fuel with a net available heat of almost 4000 BTUs per pound of solids. Drying sludge also permits high flame temperatures (2000 to 3000 °F), thereby improving the quality of the flue gas by maximizing the destruction of any toxic compounds present.

The C-G Process facility at the City of Los Angeles is designed to handle over 400 dry tons per day of sewage sludge derived from 3.5 million people living in a 600 square-mile area. The dried sludge is fed to a fluidized bed gasifier which employs recycle flue gas followed by two stages of after-burning. This staged combustion of the pyrolysis gas results in minimum NO_x formation and results in air emissions below those experienced prior to this energy-recovery project. The design energy equivalent of the dried sludge is over 1000 barrels of oil per day.

PEAT DRYING

Most of the peat used to produce energy today is sun-dried in production fields. This method is obviously highly dependent upon the weather and has a short production season, especially in northern countries such as Finland. Working with the Technical Research Centre of Finland, laboratory and pilot plant tests were conducted to demonstrate the effectiveness and efficiency of the C-G Process in drying peat.

One of the important side benefits of the C-G Process is its ability to extract compounds from the solids during the drying steps. Bitumen is a major constituent of peat which can be extracted. Extracting bitumen prior to combustion or gasification is an advantage since the bitumen can be sold as a valuable by-product and it minimizes waxy depositions in the combusting equipment.

Studies were done to determine the solvent which optimizes total process performance. Iso-octanol was found to provide the best balance between bitumen extraction, fluidization capabilities, and cost.

REFINERY WASTES

Several tests have demonstrated the ability of the C-G Process to dry and detoxify refinery wastes, such as slop oils, DAF sludges, API separator bottoms, tank bottoms, bio sludges, and primary/secondary emulsions. In one typical study, a hazardous oily sludge was taken from a refinery wastewater pond in the Northeast and tested in DTC's laboratory. As shown in Table II, the material contained 1.3 pounds of indigenous hydrocarbons per pound of solids. One sample was treated with solvent once. A second sample was treated with distilled solvent twice. The concentrations of indigenous hydrocarbons in the solids were only 2.0 and 0.2 weight percent, respectively, after treatment. The original slop oil was unsuitable for landfilling due to the presence of a variety of hazardous hydrocarbon compounds. After treatment by the C-G Process, an independent testing laboratory determined that both solids samples met all the requirements for non-hazardous landfilling as specified by the U.S. EPA. The extracted indigenous hydrocarbons can be recycled to the front end of a refinery or burned as high BTU content fuel.

CONCLUSIONS

The C-G Process, licensed by Dehydro-Tech Corporation, is a versatile process for drying and solvent extracting wastes to produce fuels and byproducts. It has been used for a wide variety of applications and is being considered for new applications, such a peat and refinery wastes. The technology should play, a growing role in the "waste to energy" markets.

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TABLE I
CARVER-GREENFIELD PROCESS WASTE TO FUEL APPLICATIONS

Location	Capacity (US DTPD)	Feed Type	Feed Solids (wt%)	Product Use	Startup Date
Los Angeles	420	Digested municipal sludge	19	Combustion for electricity generation	1992
Japan	50	Undigested municipal sludge	20	Combustion for energy and cement additive	1989
Italy	1.3	Digested municipal sludge	40	Combustion for electricity generation	1988
Los Angeles	400	Digested municipal sludge	20	Combustion for electricity generation	1987
Russia	48	Dye wastes	14.3	Fuel	1986
Italy	55	Dye waste sludge	20	Fuel	1985
Virginia	20	Bio-sludge and wool scouring waste	2	Fuel and lanolin	1985
Denmark	1	Refuse derived fuel and sewage sludge	10-50	Utility boiler fuel	1985
Washington State	50	Wood pulp mill activated sludge	13	Animal feed and fuel	1979
Indiana	24	Pharmaceutical plant wastes	2-4	Fuel	1978
Pennsylvania	0.3	Chocolate waste	2	Fuel	1978
Colorado	30	Brewery undigested sludge	4	Animal feed and fuel	1977
Japan	15	Undigested and digested municipal sludge	4.5-5	Utility boiler fuel	1976
Japan	25	Primary sewage sludge	2	Utility boiler fuel	1975
Mexico	7.2	Pharmaceutical wastes	6	Fuel	1975
Japan	1.3	Primary sewage sludge	20	Fuel	1973
Indiana	9.6	Pharmaceutical wastes	2-4	Fuel	1970
Pennsylvania	10	Undigested air floatation sludge	8	Utility boiler fuel	1964
Total	1,167.70				

TABLE II
SLOP OIL TREATMENT RESULTS

Component	Feed Composition (weight percent)	Treated Solids Composition (weight percent)	
		Treated Once	Treated Twice
Solids	12.0	97.8	99.6
Indigenous Hydrocarbons	16.0	2.0	0.2
Water	72.0	0.1	0.1
Solvent	0.0	0.1	0.1
Total	100.0	100.0	100.0

FIGURE 1
SIMPLIFIED CARVER-GREENFIELD PROCESS FLOW DIAGRAM

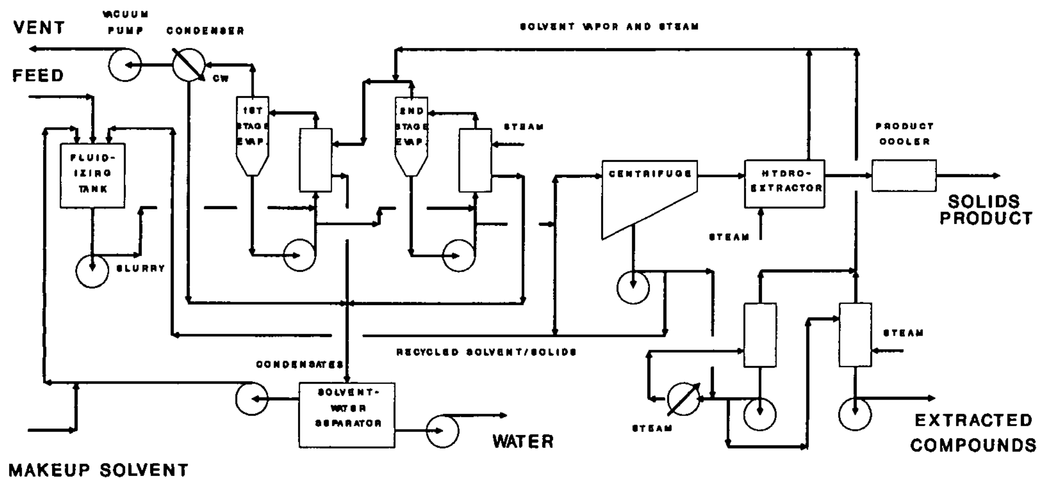
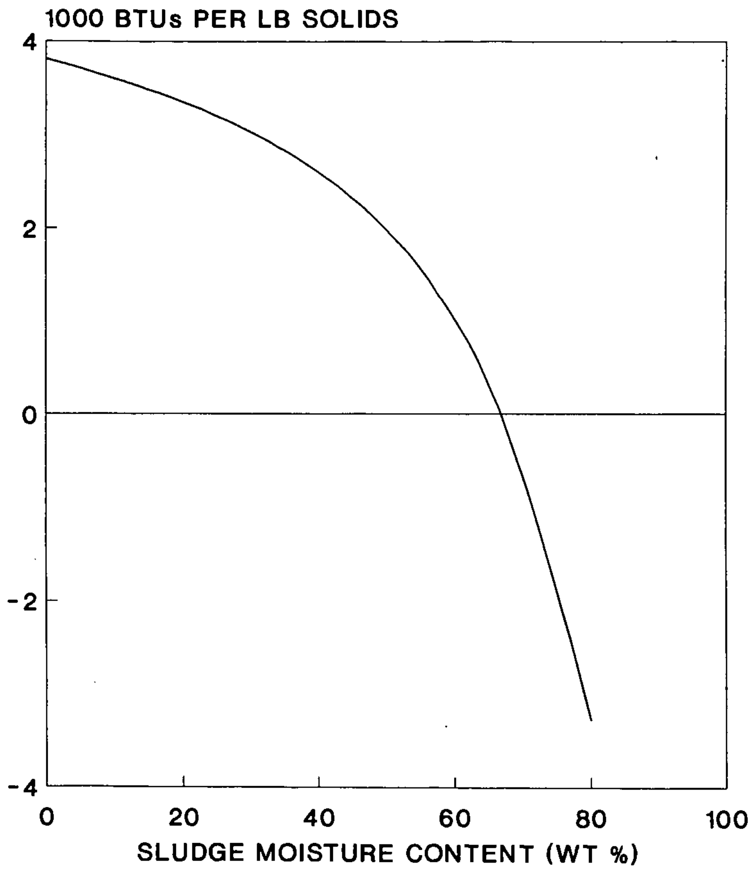


FIGURE 2
NET HEAT AVAILABLE IN SEWAGE SLUDGE



BASIS: 1400 DEG F, 50% EXCESS AIR