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Cavitation Technology for Waste Processing and Power Generation

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Currently, one of the most promising areas of recycling is the transfer traditional sterilization technologies for the processing of municipal solid waste.

The development of these technologies in the recycling of household waste goes in two directions: the first is associated with the development of autoclave technologies to effectively decompose the waste into fractions; the second one is to use the technology of the boiling debris from the pre-shredded garbage mass.

In the autoclave technology companies are the absolute leaders EstechUSA, Babcock (UK), Ambiensys (Spain), Sterecycle (UK), WastAway(USA) [1,2].

Autoclave technology is the mass in garbage handling autoclave at pressures of from 4 to 7 bar of superheated steam at a temperature of 120 to 200 C.

In the most basic applications as the primary treatment vessel is used the horizontal rotating autoclaves combined with some debris grinder. In the processing of plastic bottles pulverization occurs, packets, boxes, etc. and their partial softening and melting. Organic wastes decompose into cellulose, lignin and other fractions, wherein the cellulose content after autoclaving is 50% [3,4].

After “autoclaving” the average volume of municipal waste is reducing up to 70%. The waste mass is completely sterilized and free of infections.

After 'overheat steaming' the steam flow is stopped. For cooling used the special condenser. In one of the applications the condenser is the one of the element for heating steam for the second autoclave [5,6].When depressurized the autoclave door is opened. Rotating drum makes it easy to download “steamed post-waste” material to processing for subsequent fractionation. So, 'steamed post-waste”' material can be discharged and separated by a series of vibratory areas (trommel screens usually) and recovery systems [7,8]. The “steamed post-waste” materials after vibratory separation have several valuable uses. One system claims to be able to dry the cellulose during processing using “dry” overheating steam. Another system is able to dry the cellulose using centrifugation. The second system is more economically.

Separation of the cellulose fibers is carried out in a stream of air which blows the lighter cellulose fiber fraction. The heat, steam and rotating action of the autoclave vessel strip off labels and glues from food can provide very high quality ferrous/non-ferrous fission.

Further separation of “steamed post-waste” plastics and glass also produced on vibrating screens.

For separation ferrous materials used electromagnets, for separation non-ferrous metal particles used Foucault current devices.

The full process of loading, treatment and separating is typically completed within 90 – 120 minutes. Usually it used autoclaves of 0.5; 2; 6; 12 and 36 cubic meters for plant with annual processing volume 1,200; 4,800; 15,000; 30,000 and 120,000 respectively.

Another method of using of sterilization is the "cooking" process. A significant advance in this technology has made the company Vickers Seerdrum (UK).

The main feature of the technology is a decoction of garbage at a temperature of 75 – 95˚C. As a result waste treatment process is required more and more lower capital and operating cost, no pressure vessel engineering, no odorous condensate disposal cost, no glass and melted plastic fragments which pass out with the cellulose fibre etc.

However none autoclave technology or technology pulping are not widely development in the world. There are only a few plants working on these high-temperature processing technologies. The reason is the significant energy consumption and high technological complexity of the equipment and the complexity of the control programs.

Further promotion of high-temperature sterilization technologies to processing waste is developed at our Moscow University of Information Technologies, Electronics and Automatics (MIREA) cavitation ones.

A cavitation technology of municipal waste proceeding provides significantly reducing of power consumption and simplifies and reduces the cost of equipment operation. Waste treatment by cavitation technology is conducted inside a rotating column operating without the addition of large volumes of water and without raising temperature above 50˚C due to its own moisture collector.

Cavitation bubbles are created by the action of the combination of microwave and ultrasonic radiation on the flow in the pre-shredded garbage under the influence of the alternating electric field. Then this mass of debris flows in the low-temperature horizontal rotating vessel with the additional mechanism for grinding.

The key element for cavitation bubbles forming is piezotransformer [3,4]. (fig.1).

Pressure necessary for decomposing of garbage particles creates on the base of producing water drops on the surface of garbage particles above. These drops in the cavitation fluid are obtained by intense ultrasonic waves method. In this case, the waste flow is handled by the variable electrical field.

Waste stream is heated by microwave radiation. This is the additional factor in the formation of cavitation bubbles.

Liquid flow which is injected into the cavitation vessel also is incurred to ultrasonic, electrical field and microwave influence to cavitation bubbles creation.

As a result alternating phases of compression (compression) and the dilution cavitation bubbles is created. The average bubble diameter is approximately 1 mm.

During the collapse of the bubble (the collapse time can vary from a few nanoseconds to tens of microseconds) they contain gas can be heated up to 6000 - 7000^{o}C (for comparison surface temperature of the sun is 5500 - 6000 ^{o}C).

Fig.1 Piezotransformers with autoelectronic emission

Using of piezotransformers with autoelectronic emission provides to form more than 10^5 cavitation bubbles and reaction temperature up to 6000 – 7000 ^oC

When these cavitation bubbles on the surface of waste small particles and larger pieces and bubbles created in the water pipes inject to processing vessel it can give such a rapid relative movement these particles and larger pieces (especially organic, plastic, stone and metallic), they will be destroyed and even melted in a collision

Ultrasonic waves with microwave and electrical “pumping” are also able to create microscopic and nanoscopic "pockets of high-temperature elements" in a cold liquid or in bubbles inside ice. This may be way to develop waste proceeding vessel without any heating but on the base crashers only (with special tools, of course).

Moreover these effects of ultrasound are caused by physical process of liquid arise, grow and collapse gas and steam bubbles.

The required pressure to destroying of waste particles is depending on the type and purity of garbage or liquid on the surface of waste particles and water inside operation vessel. It is very useful for further separation process to obtain separate fractions of cellulose, plastic, glass, metal and stone.

As a result there are two proceeding vessels is required. The first one is for primary treatment the “continuous throughput” and the second one used for separation and drying.

Cavitation process used the more simple equipment as waste autoclave process or cooking process. Comparative characteristics can be viewed in table below.

Description	Autoclave Technology	"Cooking" Technology	Cavitation Technology
Capital Costs	High	Middle	Low
Operation Cost	High	Low	Low
Process	Batch	Continuous Throughput	Continuous Throughput
Vessel Types	Rotating, high pressure, high temperature	Rotating, non-pressure, high temperature	Rotating, non-pressure, low temperature
Process Temperature, °C	120 - 200	75 - 95	20 – 50 (may be from -50 to +50)
Heat Input	Overheating steam	Hot Water	Ordinary tap water, heating is not required
Heat required per Tonne MSW, GJ	1	0.1	0.001
Process Water	High quality	Low grade	Low grade
Organic Fibre Product	With melted plastics	Without melted plastics	Without melted plastics
Condensate Production	Yes with high disposal costs	None	None
Potential for Incineration or Pyrolysis	Fibre only	Fibre only	Fibre, Plastics, Tyres and Resins due to good plastic types separation (the secondary proceeding)
Fibre Potential for Biogas	Good	Good	Good
Fibre Potential for Biogas	Poor due to plastics contamination	Poor due to lignin contamination	Good

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