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The flexibility of plasma

Amiel Bénédicte

Thermal treatment of asbestos waste and fly ashes

Vitrification using a plasma torch can transform waste material intoan inert, environmentally stable product. And what's more, thisproduct has a market in the construction industry, as BénédicteAmiel explains

One company that has put this concept to good use in the treatment of residues from the incineration of municipal solid wastes (MSW) and asbestos wastes is France-based Europlasma.

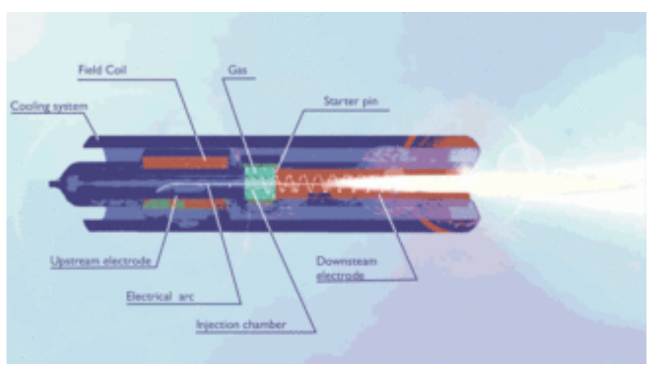

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Figure 1. Dissecting the non-transferred arc plasma torch

What is plasma?
Plasma is a very hot gas characterized by the ionization of its atoms. Lying in a fourth state (compared with standard solid, liquid and gaseous phases), thermal plasma has higher energetic densities and capacities of heating than conventional heating tools such as burners with fuel oil, gas etc. It is obtained by heating air with an electrical arc maintained between two electrodes.

Torches manufactured by Europlasma are of tubular type with a non-transferred arc. This technology is characterized by a complete separation between the electrical arc, which remains confined in the torch between the two electrodes, and the bath of products that undergo fusion in the furnace. Only the plasma plume is in contact with the wastes being treated.

Europlasma's plasma torch technology (see Figure 1) was first developed in the 1980s by EADS — a French aerospace company — to simulate the intense heat encountered by missiles and spacecrafts during atmospheric re-entry. Europlasma was founded in 1992 to develop and apply this specific lab plasma-torch technology to industrial processes such as waste treatment. As part of this technology transfer, torch performances and maintainability have been highly improved, particularly in the development of specially designed maintenance tools and in the increase of electrode lifetime.

For over a decade Europlasma has been working on hazardous waste destruction using the high temperatures provided by its blown arc, high-power plasma torches. While tests have been performed on asbestos, ashes (from incinerators and gasifiers), low radioactive waste, chemical weapons, medical waste and organic chlorides, the company has invested particularly in the handling of asbestos-containing materials and ashes. This has resulted in the erection of industrial vitrification plants in both France and Japan.

Using plasma in the disposal of asbestos

Asbestos is a natural fibrous rock, valued for its resistance to high temperatures, chemical attack, micro-organisms and wear. The danger represented by asbestos does not lie in its chemical composition, but in its physical properties. Asbestos fibres settle at the bottom of the lungs and remain in the pulmonary fluid for more than 30 years after inhalation. Asbestos is a carcinogenic fibre and is classified as a hazardous waste.

The process of asbestos vitrification

Interestingly, France was the first country in Europe to ban asbestos (banned from 1 January 1997), and a treatment plant for asbestos wastes in Morcenx, France has been active for over ten years. Run by Inertam, a subsidiary company of Europlasma SA, the facility began operation by treating up to 8000 metric tonnes of asbestos-covered waste per annum. Since 2001, throughput has increased to more than 25,000 tonnes of asbestos-covered waste and more recently the site has expanded further, with the addition of a third processing line. Inaugurated in November 2005, the new line alone is able to treat up to 42 tonnes of asbestos-covered waste per day.

Waste arrives at the treatment plant pre-sorted. All waste is then crushed to the correct dimensions for entry into the vitrification process and is introduced to the furnace by an automatic system. This is what makes vitrification of such interest — 100% of the waste is processed and totally transformed into the resulting glass-like product. The furnace is heated by three plasma torches (two torches of 2MW and one of 500kW) and maintained at a temperature appropriate to the physicochemical characteristics of the wastes being treated. The piloting of the installation is carried out by computers in a dedicated control command room. Regulation of the functioning parameters of the furnace and torches is overseen by a posted operator. The furnace works semi-continuously: waste is constantly added to the furnace and the output is tapped about every hour. After exiting the furnace, the vitrifiat produced — termed Cofalit by Europlasma — is kept in a storage area for cooling.

Cofalit has been shown to be non-hazardous, and has the appearance of black glass or a basaltic rock. With excellent chemical, physical and mechanical qualities, it is sold as an aggregate for road foundations or incorporated in the manufacture of other construction products, such as flagstones.

The costs of plasma treatment for ashes

The costs per tonne of treating fly ashes using plasma-torch technology are highly dependent on the capacity of the installation, its availability, the consumables used, and the nature of the ashes. Such costs are specific to each project. The price is between 15% and 25% higher than that of landfilling when the unit is integrated in an incineration centre. Nevertheless, this extra cost should be seen against the environmental advantages of the process and the fact that the vitrified waste is a useable product that is sold as a road building aggregate.

Ash melting with Europlasma

As mentioned earlier, Europlasma has also targeted its technology to the disposal of ash from incineration, which is generally hazardous because of the many heavy metal pollutants (lead, zinc, copper, mercury) that are concentrated in the ash during incineration.

above Vitrifiat at its melting point

Treatment of such wastes is becoming increasingly important in today's environment. Waste-to-energy facilities are being increasingly scrutinized and held accountable for the image they convey and for their environmental impact. Indeed, many stakeholders within and outside the waste industry are sensitive to the issues associated with incinerating waste. Solutions must be considered in the context of sustainable development. As a result, in more and more countries worldwide, regulations are evolving that focus upon the disposal of residues from waste-to-energy plants as well as from older incinerators that do not recover energy. Ash melting technology keeps pace with this thinking, offering a disposal solution that meets such tough standards.

The process of ash melting

Fly ashes are introduced continuously into the furnace (as before). In the central part of the furnace, one plasma torch generates thermo-chemical reactions and brings the ash material to its melting point. In this case, the temperature of the melting bath tends to be 1400°C to 1500°C, i.e. about 500°C above the temperature of incineration of the MSW. (The temperature required in plasma treatment depends on the melting properties of the materials being treated.)

The impact of the plasma plume on the ashes leads to thermal transfer and the generation of good quality vitrifiat in an oxidized environment. After rapid cooling of the vitrifiat — in this case termed Plasmalit by Europlasma — the pollutants contained in the material are once again immobilized so that the vitrifiat can be considered inert.

Europlasma has developed its activities in ash treatment principally in Japan in conjunction with partner companies Kobe Steel and Hitachi Zosen. It has offered diverse input, including the provision of the torch, designing the furnace, licensing use of the technology, and providing technical assistance for smooth operation. Four sites in Japan have been developed along these lines, with capacities between 10 tonnes and 42 tonnes per day. Also, in France, Europlasma has built a unit in Cenon, Bordeaux, (see photos, above) with a capacity of 10 tonnes per day

A useful and valuable end product: Plasmalit

The end product from plasma treatment of fly ash is termed Plasmalit and, like Cofalit, it is considered non-hazardous (according to the European classification of wastes). Plasmalit is attracting interest from manufacturers of concrete products because of its shiny black appearance, as well as its mechanical and environmental qualities. It is possible to integrate this material in the production of flagstones or paving stones to produce a natural-granite substitute. Plasmalit differs from Cofalit in that the former has been cooled down rapidly and appears like glass. Cofalit has been cooled down more slowly and looks more like basaltic rock.

left to right The asbestos vitrification line run by Inertam in Morcenx, France n Cofalit: an inert and non-hazardous vitrified product n The ash melting unit in Cenon, France

Europlasma is currently working in partnership with an Italian laboratory to use this material in architecture for acoustic and thermal insulation. A special study conducted by a committee of 15 members under the title ‘The Vivaldi programme’ explored the properties of Plasmalit. It highlighted the inert nature of the material (an important property if landfill disposal is required) and when examining long-term behaviour the material showed results similar to natural basalts whereby Plasmalit is non-hazardous over the long-term i.e. it is stable for more than 200,000 years.

Market outlook for plasma treatment

Thermal treatment of waste by plasma offers the industry a new way forward in terms of effective waste management. New applications are emerging, including, for example, the application of this approach to the treatment of sewage sludge. A licence has been signed by Europlasma and a Korean partner to install a sewage sludge treatment unit in the city of Yongin, South Korea.

Also high temperature solutions are being considered for removing tars and improving the purity and energetic quality of the syngas after gasification of wastes. The combination of a high temperature and an ionized gas exiting the torch supports a quick reaction time of the chemical components and the recomposition of the syngas into carbon monoxide and hydrogen. The purer the syngas, the better the yield of the gas turbine. Turbines work with CO and H_2 (CO_2 is an inert gas and is not suitable for driving the turbine), while syngas is composed of CO, H_2, CO_2 and CH_4 (plus a few minor components). Purifying the syngas gives a higher proportion of CO and H_2 and thus improves the efficiency of the final process. A dedicated research and development team at Europlasma is working on this new application, which has been named Turboplasma. Two projects using Turboplasma have been launched in 2007 and interest in this field continues to grow.

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