Beneficial Utilisation of Sasol Coal Gasification Ash

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ABSTRACT

Sasol utilises low grade coal in a Lurgi gasification process to produce synthesis gas from which ash is an inevitable co-product. Gasification ash, referred to as coarse ash, is a clinker ash with heterogeneous texture varying from fine material to large irregularly shaped aggregates. Ash utilisation opportunities can be separated into off-site use as a product replacement or on-site through the utilisation of ash dumps to treat waste products. The large scale opportunities for the off-site use of gasification ash is in brick making, as road fill and other construction applications. As a commodity input its market penetration is very price sensitive due to transport costs. Geographical location of the ash source largely determines off-site ash utilisation opportunities. Within large ash disposal sites there exists significant opportunities to beneficially utilise on-site the top layer of an ash dump for the treatment and disposal of wastes such as bio-solids. This in turn can improve the ash properties to make it more suitable for rehabilitation and research in this area is being pursued. Environmental risks associated with ash utilisation include leachate (surface and ground water contamination), dust and loss of arable land. These risks are definable and in most cases low and controllable. Gasification ash remains a valuable under utilised co-product and its responsible use is encouraged particularly in exploiting its unique properties.

INTRODUCTION

Coal ash is an inevitable co-product of the Lurgi coal gasification process employed by Sasol to produce synthesis gas from low-grade, high ash coal. Approximately 28 million tons of coal is consumed annually by the gasification process at Sasol Synfuels in Secunda producing 7 million tons gasification ash. Approximately 6 million tons of coal is annually gasified by Sasol Chemical Industries in Sasolburg producing 1.5 million tons ash although this practice is being discontinued due to the introduction of natural gas to this plant. The remaining 30 % of coal utilised, a finer coal fraction, is combusted to produce steam and electric power required by the process.

Gasification ash, referred to as 'coarse ash', is a combination of red and white to grey fused clinkers with heterogeneous texture varying from fine material to large irregularly shaped aggregates of sizes ranging from 4mm to 75mm. This ash comprises predominantly of an assemblage of major oxides (quartz, mullite, and anorthite) and minor oxides (diopside, hematite, cristobalite) and anhydrite. These materials contain between 4 – 7% of unburnt carbon containing coal minerals and trace quantities of a number of trace elements. There are notable differences in the physical, chemical and mineralogical characteristics between gasification ash and fly ash produced at the steam plants.

BENEFICIAL UTILISATION OF ASH

Significant costs are associated with the handling and disposal of ash and Sasol has continuously been trying to identify beneficial utilisation opportunities for ash. The utilisation of ash is not an alternative to disposal but is justified when it can be used as a suitable product replacement. In most cases the potential markets are small in relation to the amounts requiring disposal. Ash utilisation opportunities can be separated into:

- Off-site application of ash largely as construction and fill material.
- On-site (*in-situ*) utilisation of ash dumps to assimilate and treat applied wastes.

Some of the more prominent ash utilisation opportunities are discussed in the next sections.

Ash cement bricks and road fill

It has been demonstrated that coarse ash is ideally suited as fill material in cement bricks and is currently the main market for this ash. In the Vaal Triangle area there exists a well established brick manufacturing market where between 2 to 3 million ash cement bricks are made per day, most of which contain screened gasification ash from the Sasolburg site. Gasification ash is being used as a selected sub-grade and in some applications as a sub-base in roads. It is also used as a substitute for:

- Bedding material for paving bricks and in floor screeds.
- As a general fill material (non graded low level fill).
- General use in low strength concrete.

Currently the volumes of ash sales for the Sasolburg site is about half of the volumes produced. This market is largely driven by its geographical location since, as a commodity input to the cement brick and road material market; it is very price sensitive to transport costs. Location to markets primarily due to prohibited transport costs limit the utilisation of ash from Sasol Synfuels in Secunda and most of it is landfilled. The Sasolburg coarse ash dump has, however, been on a low growth for the past few years due to the strong local demand for the product since it is by far the greatest source of coarse ash in the area. It is anticipated that towards the end of the decade when much of the alternative ash supplies in Gauteng would have been depleted, then utilising ash from Secunda may become a more viable option.

The large variability in the grading of the ash product requires that in many applications screening of the material is to be done prior to its use. A pilot process was developed to produce a high quality graded material from gasification ash producing a quality guaranteed product that could, apart from being used for brick making, be used in the base layer of roads and in medium strength concrete . The process involves the screening and re-constituting of two grades of ash with a portion of fly ash. The material is referred to as Premamix and while this potential process has a number of advantages the capital intensive process cannot compete economically with current ash screening and utilisation practices.

Fresh coarse ash cannot be used for making cement bricks and this ash has to be aged (weathered) for a period of 3 to 6 months prior to use. The “popping” phenomena experienced when bricks are made with fresh ash are explained by the formation of expansive minerals on weathering/ aging. This can readily be resolved by allowing the natural carbonation process to proceed to completion through natural weathering.

Other large scale ash utilisation opportunities

An ever increasing number of uses for ash are becoming available. They are, however, mostly for high value low volume applications. Other larger scale ash utilisation opportunities that have been considered in the past or are currently being evaluated include:

- The manufacture of light weight aggregates for use in concrete building materials (investigated but found not to be economically viable).
- Use of gasification ash as a cement extender (current research activity).
- Placements of ash into old underground mine workings (currently being evaluated).

Research into utilising ash dumps to treat wastes

As mentioned the geographical location of an ash source has a large influence on off-site ash utilisation opportunities. It is, however, unlikely that one would ever be able to sustainably remove the entire quantity of ash produced. In many instances, such as in Secunda, the ash utilisation market may be negligible compared to the quantities landfilled. In these cases ash disposal by landfill is the accepted practice, and within

these large ash disposal sites there lie opportunities to utilise ash for the treatment and disposal of wastes.

One opportunity being investigated is the co-disposal of ash with excess bio-solids from the biological activated sludge waste water treatment process at Sasol Synfuels in Secunda. The opportunity lies in utilising the organic sludge for improving the organic matter status of the top layer of the coarse ash dump so that a sustainable vegetation cover can be established for rehabilitation and final closure purposes. Controlled plant growth field trials conducted to evaluate this concept have shown promising results. Sludge amended ash has been shown to support plant cover in a significantly better manner which could substantially reduce final rehabilitation costs. The large size of the coarse ash dump in Secunda (at final stack height about 7 Ha/annum will be available for rehabilitation) provides ample space to treat the excess sludge which is currently incinerated. Other waste treatment and disposal opportunities for which ash dumps are potentially suited include:

- Use in the Solidification/Stabilisation of sludge containing hydrocarbon wastes for treatment and final disposal purposes.
- Co-disposal of sulphur containing wastes whereby the acid produced through sulphur oxidation, neutralises some of the alkalinity of the ash to create conditions that are more beneficial to supporting plant growth.
- Controlled irrigation of brine on an engineered disposal field located on an ash dump where capillary barriers are used to intercept the irrigated brines.

ENVIRONMENTAL CONSIDERATIONS

Ash has no inherent quality per se except in the context for which it is used. For most utilisation and disposal applications the main areas of environmental concern associated with ash are leachates (surface and ground water contamination), dust, loss of valuable land (including aesthetics) and radioactivity issues. The following points are important to take into account when considering environmental issues associated with ash:

- The fraction of leachable trace elements is small compared to the total concentrations of trace elements contained in the ash.
- The quality of ash leachate significantly improves with time/aging (particularly reduced alkalinity and ion (salt) leaching).
- Ash has, if any, small quantities of salt polluting or generating minerals (unlike various mine waste residues).
- The quality of the water used to transport the ash strongly influences the ash leachate chemical characteristics.
- When comparing ash with substitute products, ash does not have significantly worse chemical characteristics.
- Dust can be suppressed through covering the dumps with a vegetation cover or water spraying.

While ash is a highly suitable material for a number of applications and the environmental risks are definable, low and controllable, there are situations where its

use is inappropriate. A risk based approach is preferred when assessing potential environmental impacts, to ensure appropriate use of the material within technical and regulatory requirements.

CONCLUSIONS

Gasification ash is a valuable under utilised co-product and its responsible use is encouraged particularly in exploiting its unique physical properties. There are large opportunities for the off-site use of gasification ash in brick making, as road fill and other construction applications. The poor consistency of the grading properties can readily be corrected through screening. The beneficial utilisation of ash dumps for treating and disposing of selected wastes offers some waste handling opportunities and research in this area is being pursued further.