Development of Manufactured Aggregates Using High-Intensive Mixing

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INTRODUCTION

New to the utility sector, but used for many years in industrial processes, high-intensive, counter-current mixing technology is proving to have multiple CCR processing applications. The high-intensive mixer’s pelletization capability is of particular interest.

Bottom ash and fly ash can pelletize in less than five minutes with only the addition of a small percentage of water. Or, varying amounts of strengthening materials — such as cement kiln dust (CKD), Class C Fly Ash and Portland cement — may be added to improve the durability of the new lightweight aggregate or normal weight aggregate. The market value of a new ASTM-certified aggregate product is easily weighed against the cost to produce it; the individual characteristics of a given ash product determine the pelletization costs, related mostly to the amount of strengthening or “binding” additives needed and the pelletization time. Once final ratios are determined, the program’s viability is clear.

The mixer’s counter-current mixing action is a highly effective method for producing consistent uniformity, thoroughness and rapid mix time, with less moistures and additives. Simply stated, counter-current action occurs when the pan rotates in one direction, while the fixed-position mixing tools rotate in the other. Processing times can be greatly reduced while providing a more homogenous batch. For the purposes of beneficial reuse, a very popular application of the mixer is to first homogenize a mix and then pelletize or agglomerate the material to form pellets – all in one machine.

Utilities generating fly ash or bottom ash are well-advised to consider the manufactured aggregate market, and to find the most efficient processing technology for production.

IMPROVED RESIDUAL USAGE

A key goal when attempting to develop a lightweight or normal weight synthetic aggregate from a byproduct source is to maximize the amount of byproduct(s) used and minimize the use of additional blending ingredients. There will almost certainly be a
need, in most cases, to add enhancements to coal combustion residuals (CCRs) in order to create an end-product with marketable characteristics. For example, Portland cement or Class C Fly Ash combined with daily production CCRs gives aggregates the hardness and durability necessary to produce a viable product.

It is without question that Portland cement and Class C Fly Ash can be used to produce aggregates; however, the feasibility of a beneficial reuse program hinges on the quantity used. The CCR to Portland cement ratio or "blending ratio" must be tightened repeatedly during the product development phase, to use as much of the targeted byproduct as possible and as little of any other ingredient as the formulation permits. High-intensive or "high shear" mixing technology allows for the efficient and cost-effective use of blending ingredients. The mixer’s counter-current mixing action combined with the level of energy exerted on the materials makes for the exceptionally even distribution of all ingredients, and therefore less Portland cement, Class C Fly Ash, etc. is necessary to realize the benefits of these additives.

PONDED RESIDUALS

The versatility of high-intensive mixing technology is best demonstrated by the many different ways CCRs are combined to make end-products, specifically lightweight and normal weight synthetic aggregates. With increasing internal and external pressure to close coal ash impoundments, this technology is well positioned to play a significant role in the beneficial reuse of ponded CCRs.

Figure 1

In 2014 a study was conducted in which ponded CCRs were combined with daily production CCRs — dry fly ash — and a small quantity of Portland cement. The resulting product (Figure 1) showed the potential to make both lightweight and normal
weight aggregates that adhere to ASTM technical standards and specifications, specifically the ASTM C33 / C33M standard specification for concrete aggregates. During testing, the dry materials — daily CCRs and Portland cement — were first combined in the high-intensive laboratory mixer to achieve uniformity. Then the “wet” or ponded CCRs were added. It was found that adding the materials in two steps allowed for the very small amount of Portland cement, Class C Fly Ash or Class C Fly Ash, to become highly homogenized, leaving no unwanted pockets of the aforementioned binding agents. Utilizing two CCR sources to manufacture one or more end-products is a notable advancement for beneficial reuse. With one technology, utilities can make use of two byproduct sources – the ponded CCRs and the daily CCR stream. And from this singular technology processing these two sources comes the potential to make multiple lightweight and normal weight synthetic aggregates depending on market demand – all with one system.

MATERIAL HANDLING PROCESS

The manufacturing of synthetic aggregates using high-intensive mixing technology is a simple batch process. Two surge bins, equipped with live bottoms, are respectively filled with the dry materials and wet materials by plant personnel operating a front end loader (dry materials may also be introduced from silos). The dry materials are then dispensed onto an inclined weigh belt conveyor via the surge bin’s live bottom. Once the conveyor feeds the mixer, the dry materials are mixed for a short period of time. Then the wet materials are dispensed onto an inclined weigh belt conveyor via the surge bin’s live bottom. This inclined weigh belt conveyor is equipped with a moisture sensor. The wet CCR’s actual moisture will become a mix control PLC factor for computing the overall mix moisture. Once the wet ingredients are conveyed into the mixer more water may be added automatically as per the mix formulation and the moisture sensor’s reading. Then mixing and pelletizing — which occur consecutively in the same unit — takes an average of one to five minutes depending on the design formula. The uncured or “green” pellets are then discharged from the bottom of the mixer to be stockpiled or conveyed through a fluidized bed dryer. Once air drying or curing in the dryer is complete, the pellets are screened and/or crushed to meet the given gradation specification.

These are the key steps in the process of producing aggregates using mixing technology. A complete system, which has already been designed for some applications, also may make use of other elements including; a bulk bag loading system, a screening and crushing system for oversize pellets and a fines/dust recycle bin which receives process fines and dust from the screen separator outlet ports.

END-USE PRODUCTS

The quality of the resulting aggregate(s), the specific end-use and the value of the material in the marketplace are all dependant on the quality of the CCRs going into the mix. The material handling system, which incorporates a high level of automation, is designed to adjust the mix design based on the characteristics of the materials being
charged. Due to the nature of ash ponds, some CCR mixes may require higher ratios of Portland cement in order to meet ASTM specifications. For large pond recovery projects a pelletization facility may include a laboratory-size version of the production mixer (see Figure 2) in order determine the appropriate changes to a mix design.

![Figure 2](image)

Once operational, the pelletization system has the capability of producing products targeted for certification under seven different ASTM specifications. The flexibility in a system that uses high-intensive mixing technology is a key factor in evaluating this beneficial reuse option when compared to other technologies. As markets demand different products, the system adjusts. As the CCR quality changes from day to day or year to year, the system adjusts. Justifying the investment in a system that produces multiple aggregates and other products is much easier than justifying a system that produces only one product – a one end-product system can become a tremendous liability if the market for that one product experiences negative growth.

As a final consideration, it is important to note that end-product materials that ultimately fail to meet ASTM specifications would, once pelletized, be stable and pass toxicity characteristic leaching procedure (TCLP) testing. These materials could then be placed in applications that include; non-structural foundation backfill, under drain, embankment and landfill construction.

Developing manufactured synthetic aggregates using high-intensive mixing technology is a worthwhile endeavor and will likely emerge as an important component of beneficial reuse and ash pond recovery projects in the near future.