Hannes Uttinger, A TEC Production & Service GmbH, Austria, provides details of the Messebo Cement Factory's fuel source diversification, which comes as part of the factory's plan to reduce its dependency on imported coal by replacing it with locally sourced combustible biomass.

A SWITCH FOR THE BETTER

Introduction

The Ethiopian cement industry is heavily dependent on imported coal, mainly from South Africa. While local coal is available, the sources are limited and of poor quality. Combustible biomass, on the other hand, is available in abundance. Sesame husk, coffee husk, the flower species Jatropha Curcas and the shrub Prospis Juliflora are some of the locally available biomass materials that could be used as a solid alternative fuel at cement plants.

Therefore, Messebo Cement Factory has started to diversify its fuel source to reduce its reliance on imported coal. In cooperation with A TEC Production & Services GmbH, the

Figure 1. View inside the shredder.

project aim was to substitute 60% of coal usage with biomass, bringing economic and environmental benefits to Messebo Cement Factory.

MCF: making the switch

The Messebo Cement Factory (MCF) is located in the northern Ethiopian province of Tigray, near the city of Mekelle at an altitude of 2300 m above sea level. The plant has a total output of 1.6 million tpy from two kiln lines:

- Line 1 – 2000 tpd.
- Line 2 – 3000 tpd.

Kiln line 1 has a single-string, five stage preheater and is equipped with a short inline calciner. Kiln line 2 has a single-string, six stage preheater with a calciner and combustion chamber.

Under the present fuel regime, Line 1 requires approximately 11.5 tph of coal, and Line 2 needs 16.8 tph. Around 75% of the plant's coal requirements are imported from South Africa and the remainder is low quality locally sourced coal. Due to high road transportation costs for South African coal from Djibouti port and from distant low-grade Ethiopian coal sources, the use of regionally available biomass holds a huge economic advantage. Biomass usage also offers significant environmental benefits.

Given these drivers, MCF has embarked on a largescale project in cooperation with Austrian engineering and technology supplier A TEC Production & Services GmbH, to substitute at least 60% of its total coal usage with locally sourced biomass.

Biomass will be used as a solid alternative fuel for both kiln lines. The initiative will be executed in a number of phases, starting with the firing of sesame straw and husk in Line 2's calciner without modification of the preheater tower or changing of existing equipment. With this first step a substitution rate of 40% will be achieved. In Phase 2 the capacity of the baling plant for supply of the biomass, as well as the shredding capacity, will be increased and, if required, modifications on the preheater will also be executed to increase the total substitution rate to 60%.

Another project phase will be the modification of the preheater tower at kiln line 1, including extension of the existing calciner. After this modification, biomass will also be fired on kiln line 1, up to 100% of fuel in the calciner (and again 60% total substitution rate in the kiln).

As a further option, MCF is now considering obtaining Jatropha Curcas waste and possibly Prosopis Juliflora from the region as additional solid alternative fuel in the midterm.

***Table 1.* Average analysis of coal and sesame straw.**

Fuels	South African Coal (%)	Local coal (%)	Sesame straw (%)
C (Carbon)	48	28	14.5
H_2	5	5	6
O_2	9.9	9.9	37
S	0.91	0.91	0.11
Cl	0.01	0.01	0.01
Ash	15	38	4.16
Volatiles			
H_2O	8	8	4.2
LHV (kcal/kg)	5800	4000	4150

Bringing in the biomass

The first type of biomass to be applied is sesame straw, which is available in large quantities in an area approximately 450 km west of Mekelle. After harvesting the sesame, the straw and husk are collected in an area comprising approximately 40 km^2, where the material is piled to be sun-dried. The dry straw is collected by the company or delivered by the farmers to the baler plant. Before transporting the material to the cement plant it must be compacted as much as possible to reduce the transport costs. Two baling presses with a hydraulic pressing force of 80 t each were installed. The presses are filled by tractor from the top.

Since there is only one sesame harvest per year, sufficient quantities of biomass must be processed within the same month and enough storage capacity must be created. MCF is already considering the use of other available biomass sources to ensure a continuous biomass supply throughout the year.

Figure 2. Feeding the biomass into the baler.

Figure 3. Biomass preparation ground.

Table 1 shows the average analysis of coal and sesame straw. As shown, the moisture and ash content of the sesame straw is very low, which means that the heating value is reasonably high.

Biomass handling and feeding

At the harvesting site the straw is pressed into bales of approxiamtely 1200 x 800 x 800 mm in size and then loaded onto trucks and transported to the cement plant. At the cement works, a 2880 m^2 capacity storage hall with a handling capacity of 4800 t has been constructed. The storage hall is based on A TEC's basic design and was planned and erected by a local contractor. Here, the bales are also handled by wheel loaders.

From the storage facility the bales are moved by a forklift truck with a special lifting device to the two shredding lines, each with a shredding capacity of approximately 6 tph. The straw bales are placed on the ground in front of a chain belt conveyor and the steel wires are manually removed. The shredding lines are specially designed for the shredding of straw to ensure an efficient and safe transportation of the straw to the following storage. The bales are transported with a chain belt conveyor to a shredder with an integrated stone trap at the discharge. From this point onwards the material is pneumatically transported to a hammer mill where the biomass is shredded to <50 mm and further on to an aspiration filter where the straw is separated from the transport air and finally fed to an intermediate storage.

To prevent the risk of fire in the storage area, a spark detection/protection system is integrated into the pipings, located after the hammer mill. For project phase two, the shredding capacity can be increased to approximately 24 tph.

The intermediate storage, which has a 350 m^3 and 35 t capacity, is equipped with a pull-rod-ladder floor extraction system. Via the ladder floor and screw conveyor, the biomass is fed to the dosing belt weighfeeder, which can be adjusted to a feed rate of 2 to 20 tph.

The biomass was transported from the dosing system to the preheater via a conventional belt conveyor. The lifting of the conveyor bridge to the preheater, which is at the discharging point about 60 m above ground, was particularly challenging. Finally the straw was fed to the combustion chamber. For airlock a rotary feeder was installed. For the purpose of safety the 'A TEC SAF feeding Swing Chute' was installed on the preheater tower. The chute works with a fail-safe system, which closes automatically in case of an emergency, such as an unexpected kiln shutdown due to power failure or an increase in pressure or temperature in the calciner. The fail-safe emergency system works without electrical power and ensures the closing of the system and heat protection of the upstream equipment in case of such operational failure.

For fire protection a complete fire detection and protection system was installed.

Influence on the pyroprocess

In Phase 1 of the project (without modification of the preheater and calciner), a total substitution rate of 40% could be realised. This is 66.6% of fuel substitution in the calciner. At a higher feeding rate in the current preheater/calciner set-up, problems with post combustion in the lower cyclone stage and eventually kiln inlet are expected, which will cause too low O_2 at the calciner exit and possible dust deposits and subsequent clogging in the lower zones of the preheater. Therefore, the preheater and calciner will be modified under phase 2, to make it possible to fire 100% of biomass in the calciner (60% of the total substitution rate) without any coating problems and still leaving sufficient margins on the ID fan.

Project progress

The biomass handling and dosing/feeding system for the first project stage is already in full operation and has been handed over to the client, and work on phase 2 has also started. The installation of additional handling equipment at the harvesting site, as well as the MFC plant, (given the use of other biomass sources previously mentioned in this article), is in the stage of final technical clarification. The modification/optimisation of Line 1's preheater for maximum usage of biomass is also currently under final technical clarification.