Tyre Derived Fuel – The Basics to Successfully Co-Process Tyre Chips

End-of-Life Tyres

Have you ever wondered what happens to all the tyres that have reached the end of their useful life?

Not too long ago, I was lucky enough to witness first hand, that more than one alternative exists to convert tyres into re-usable products. In a little shop, located deep in the north-African dessert, I found an entrepreneur who made it his business, successfully mind you, to morph this seemingly undesirable waste into a variety of buckets, sandals, necklaces and other fashionable memorabilia.

I thought for a second to invest in a Michelin armband or a pair of Pirelli sandals, but reckoned I wouldn't be able to make the expected fashion statement, while showing off my new goodies on the streets of Paris or New York, unless they came encrusted with a handful of gemstones! So, for the die-hard fashionistas you are encouraged to take a trip to this store. Who knows.

For the others, I would recommend sticking with what works, while reinforcing your cost leadership in a sustainable manner: the beneficial recovery of used tyres as secondary fuel in cement kilns.

The Options

Although the co-processing of tyre derived fuel (TDF) as an alternative or secondary fuel has been a very successful and environmentally accepted practice in the industrialized world, we know by experience that many cement kiln operators in the emerging and developing countries, either:

- Don't have the in-house expertise to position themselves as the best alternative between the tyre waste and their kilns.
- Struggle to successfully co-process larger volumes of TDF, while trying to maintain clinker capacity and maintain or reduce emissions.

TDF, which is an umbrella word, comes in various shapes, forms and costs. The most common ones used for co-processing in cement kilns are: whole tyres, tyre chips and crumb rubber.

Since very few kilns can co-process whole tyres effectively and that crumb rubber is rather expensive, we would like to go back to the basics by summarizing the key factors required to co-process tyre chips.

Why the Introduction of TDF is a Viable Energy Recovery Solution for the Cement Industry.

Fuel prices continue to rise and there is no sign of relief in the foreseeable future. Fossil fuel remains in high demand and is still the number one natural resource used today in cement manufacturing facilities worldwide. The cement industry relies heavily on coal, coke and oil to fire the kiln and can consume as much as 300,000 tons per facility, per year.

The recycling industry has made significant advances in alternative energy solutions including the use of end of life tyres as environmentally sound and less expensive alternatives to traditional fossil fuels. Scrap tyres are a problem in just about every sector of the planet as we continue to resolve the issue of eliminating existing tyre piles and newly discarded tyres from the environment.

Cement kilns worldwide account for over 50% of tyre chip use: they are ideal for co-processing as high temperatures ensure complete burnout of organics, which controls the formation of dioxins and furans, a primary concern in solid waste combustion. In addition, the cement production process can utilize the iron contained in the tyres steel beads, belts and ply. A 10 kg automobile tyre contains 1 kg of high grade steel. The iron can partially substitute the Fe203 requirement in the raw meal mix. In given quantities, these components do not change the quality of the cement.

Because of their suitability, no technical difficulties exist with the emission control techniques. Moreover, no special equipment for emission control is necessary, although it is always recommended to have good continuous emissions monitoring in place.

Key Considerations:

- Physical properties of the tyre chip: chips must be precisely cut and as free as possible of protruding wires.
- Location and the timing of introduction: 'X' doesn't always mark the spot.
- Sulfur, alkali and chlorine balances.
- Handling or injection equipment: tyre chips cause equipment to wear. Reliable equipment needs to be selected and a sluggish feed has to be prevented at all cost.

There are no general guidelines for operating technique, since the above functions are highly dependent on individual cement kiln design and requirements.

The only barrier for co-processing tire chips in cement kilns is the economic feasibility compared to other alternatives.

Physical Property

As with any other alternative fuels, physical and chemical homogeneity is key for good business. One of the main reasons tyre chips become a handling nightmare, and hence affect the bottom-line is when they look like mini-porcupines, as shown on the left picture. The chips will eventually 'ball' together, which will make it quasi impossible to properly dose the required amount of heat input. Therefore, clean cut chips, produced with a reliable shredder, will eliminate a raft of bottlenecks many cement plants are dealing with today.

An example of what will not work very well

A CM Tyre Shredder produces a 50 mm clean cut tyre chip, ideal TDF for cement kilns.

Preparation

Columbus McKinnon manufactures tyre recycling equipment systems designed specifically for reducing whole tyres into clean cut nominal tyre chips which has become the solution both in cost savings and increased production for cement companies.

CM has been building whole tyre reduction systems since 1982 and has installations in place at many of the largest cement companies worldwide including; LaFarge, Holcim, Cemex, Korean Cement, Asia Cement Sapphire and Cimpor Industries. All of these companies are actively receiving end of life tyres at their facility and processing on site. The success of CM as the leader in tyre reduction systems for the cement industry is that all CM Shredders feature the Holman™ patented knife system designed for extremely close knife tolerances which result in tyres being cut cleanly with a minimal amount of exposed wire thus, eliminating clogging or slowed delivery to the kiln.

Depending on the volume and size of TDF required on one side, and the operational and market constraints on the other, CM is able to provide the proper equipment to meet the kilns specifications. CM Tire Recycling Equipment can process a wide array of tyre sizes from passenger car tyres up to OTR tyres 1,525 mm in diameter with 50 mm nominal, clean cut tyre chip production rates of approximately 10-12 tonnes per hour.

CM Single Speed Tire Shredder – Processes passenger car and SUV tires into a 50 mm clean cut chip at a rate of 8-9 tons per hour.

A clean, consistent chip size is essential when producing TDF that is being fed into a cement kiln. Close knife to knife tolerances and superior knife materials are the two contributing factors to producing cleanly cut chips from whole tyres with no loose or exposed wire. Seen here, this double deck classification system coupled with the recirculating drum carries the oversized pieces from the classifier back into the shredder. The system reprocesses the tyre shred into the required size tire chip utilizing this compact, turnkey system.

On the Kiln Side

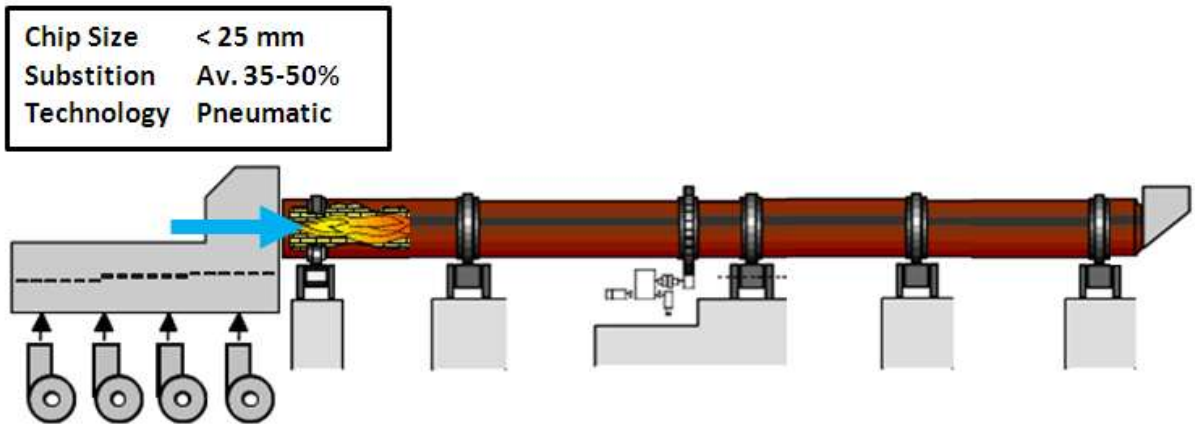
As shown in the table below, over eighty percent of a tyre is carbon and oxygen, which accounts for its rapid volatilization and high heat value. Nominal wire tyre chips contain approximately 33 Gj/t, where sub bituminous coal contains only between 27-29 GJ/t.

Fuel	TDF	Coal
Carbon (%)	83.87	73.92
Hydrogen (%)	7.09	4.85
Oxygen (%)	2.17	6.41
Nitrogen (%)	0.24	1.76
Sulfur (%)	1.23	1.59
Ash (%)	4.78	6.23
Moisture (%)	0.62	5.24

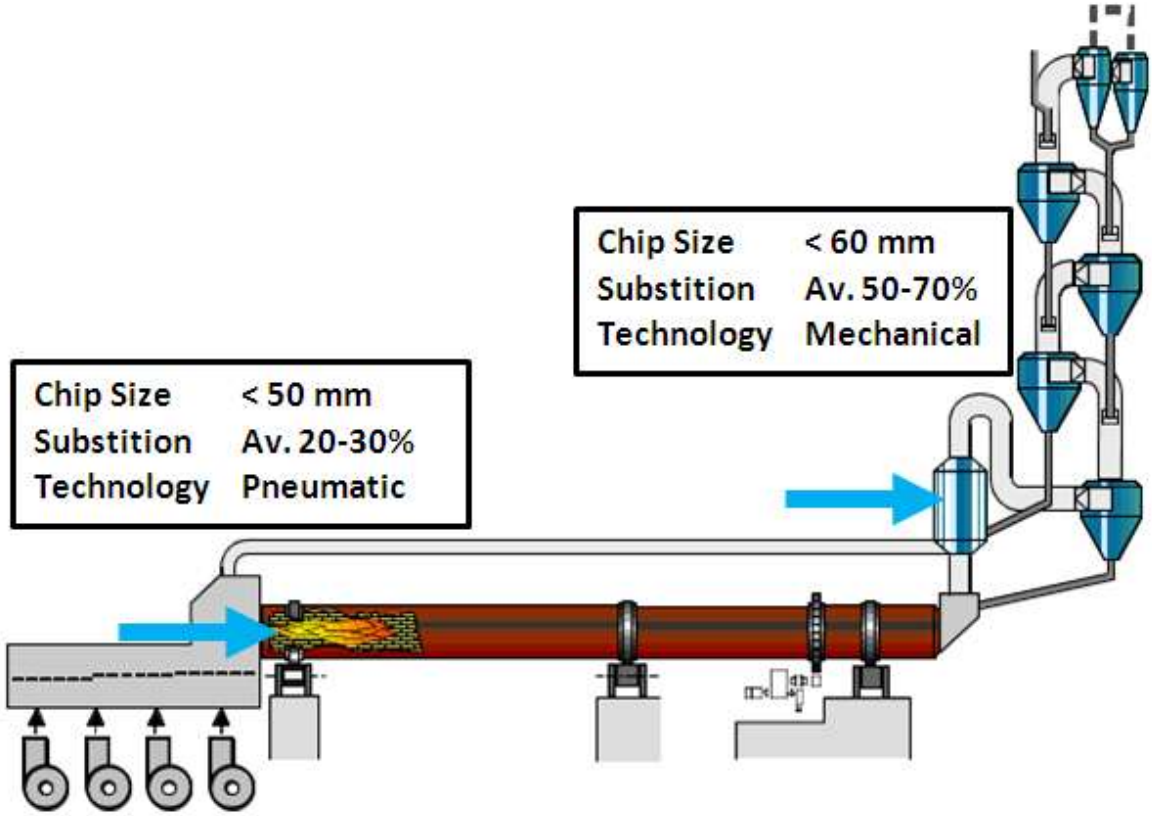
Tyre chips can be completely combusted in a cement kiln: the combination of high temperatures (1450°C to 1500°C), a positive oxygen atmosphere and a long gas residence time (4 to 12 seconds at the elevated temperatures) assures the complete combustion. With an average sulfur content of 0.5-1.5%, it is on par or less than most coals and petcokes. In terms of substitution, when co-processing tyre chips, a kiln operator can reduce coal by 1.25 tonnes for every tonne of tyre chips used. As far as emissions, tyre chips and TDF in general, are known to help reduce the NOx levels up to 30%, if injected in the right spot under optimized conditions.

Depending on the kiln system, the following rules of thumb apply with regards to chip size and potential for substitution:

Long wet or long dry kiln:



Precalciner kiln:



From a process perspective, certain constraints need to be taken into consideration to ensure success:

- Different scenarios are possible: as a non-linear rule, the smaller the chip size the higher the substitution rate can be. It needs to be noted that a 25 x 25 mm chip size, is about the smallest chip that can be produced efficiently with shredders.
- Via the main flame, the temperature, oxygen, micro mixing and time are far in excess of what is needed for complete combustion, even with the strong organic bonds. The hydrocarbon chains in TDF are similar to the ones in coal, hence as easy to break and volatize. As proven, additional mixing, or the creation of an accelerator could be beneficial for calciners.
- For long kilns, the chips need to be blown to the back of the burning zone to minimize impact on quality and SO3 cycles. Ideally, the injection pipe should be located above the main burner, at a 5-10 degree angle, so the main flame can carry the chips further and start the volatilization prior to the chips striking the load. Injection velocity of 50 m/s should be the goal.
- If one has a precalciner, injecting the chips in the vessel over the main flame is preferred. For a preheater on the other hand, main burner is preferred.
- Finally, impact of raw materials on SO2, CO, VOC, D/F's needs to be fully understood and tracked, prior to co-processing any chips

A careful kiln assessment needs to be performed in order to determine the current pyro conditions, which will result in the selection of the best injection location. To achieve higher substitution rates, it is highly recommended to perform MI-CFD modeling prior to envisioning expensive modifications to the kiln systems.

Sustainable Benefits of Using TDF

In evaluating current market prices worldwide, coal is selling anywhere between $60- 140 USD/tonne. The current average price per ton of 50 x 50 mm nominal recycled tire chips for 2010 was $24 USD/tonne. Assuming a coal cost of $100 USD/tonne and a delivered chip at $25 USD/tonne, a quick calculation shows that replacing 20,000 tonnes of coal per year, can save your company a recurring USD 1.8MM!

Co-processing TDF as an alternative energy source at your facility not only lowers your costs in a sustainable manner, but will have a direct benefit to your community. Unsightly tyre piles are a known fire hazard and can also collect water, which is the perfect breeding ground for mosquitoes and the associated diseases it can transmit. In many areas state or federal government may offer incentives for using alternative energy solutions and will work with a facility to incorporate the process. It also reduces the unsightly and hazardous tire piles. In many areas state or federal government may offer incentives for using alternative energy solutions and will work with a facility to incorporate the process.

Next Steps

Tyre chips can be used successfully in cement kilns as a fuel supplement when properly prepared and injected at the right location. With an optimized pyro-process, no production loss is to be expected and producing top quality clinker will continue to be the norm. Nevertheless, to have a successful TDF program, one shouldn't neglect the other facets of the supply chain, which is the supply and logistics of delivering whole tyres to the shredding facility.

A full assessment of the waste tyre market, supply and business value chains, and current kiln operations, will determine how a tyre chip program can be the right solution for your facility.

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