New Recycling Methods for Old Tyres

In the European Union more than 2.5 million tons of waste tyres are produced annually, from this amount almost 600,000 tons in Germany. About 270,000 tons are used as RDF in cement factories and power stations.

As the limited petroleum resources are dwindling and the energy yield is low compared with the energy required for the production of tyres, thermal utilisation of end-of-life tyres neither makes sense ecologically nor economically. Under these premises, material recycling of the main components is the better alternative.

Material Recycling of Waste Tyres

In order to recycle the tyre materials, the tyres must be crushed and then separated completely into their components rubber, steel and textile fibres. Normally, the tyres are pre-crushed in slowly running two-shaft shredders or rotor-cutters and afterwards processed to crumb and powder of different granular sizes in a single- or multi-stage grinding process. The two following processes are possible:

- Cold grinding: In this process, also known as cryogenic grinding, the pre-crushed tyre chips are made brittle by liquid nitrogen (LN2), so that they can be ground more easily in the hammer mills. In case of cryogenic grinding, one phase normally suffices for reaching the requested separation of the components and obtaining a broad particle size spectrum of rubber crumb. A disadvantage of this technology is the high cost for the use of liquid nitrogen, since one to two tons of LN2 are required for one ton of waste tyres. Besides, the small surface of the glass-like broken crumb / rubber powder has a negative effect.

Warm grinding: Warm grinding takes place at ambient room temperature. For this reason it is also called "ambient grinding". The tyre chips are crushed in fast running granulators or mills without being made brittle. By means of (cutting) granulators connected in series the product is reduced gradually to the requested granular size. The main disadvantages of warm grinding with granulators are the high energy demand due to the use of several crushing phases as well as the relatively high wear of the granulator knives causing high maintenance and wear parts costs.

The Alternative: Tyre Grinding with Flat - Die Granulation Presses

The process developed by Amandus Kahl GmbH at Reinbek for ambient grinding of waste tyres is an economic alternative to the aforementioned traditional grinding processes.

The supplied tyres are cut in a preliminary stage to a chip size of 50 to 100 mm. Via an intermediate buffer the chips are conveyed into the core component of the plant, the rubber grinding unit. Here the tyre chips are ground in a Kahl flat-die granulation press according to the pan grinder roller principle.

The tyre chips are ground between the cylindrical pan grinder rollers and the circular die designed as perforated plate. The shearing forces produced by the pan grinder

rollers when rolling over the circular die as well as the pressing forces of up to 120 bar applied by an automatically regulable hydraulic system decompose the tyre parts and separate the different components. Unlike the traditional (cutting) granulators, the material is not reduced to small pieces by geometrically shaped cutting edges, but only by the shearing forces produced between the grinding tools and in the product. As a result, the wear of the grinding tools does not have any influence on the granulation result.

The granulation press, type 60-1250, with a drive power of 2 x 160 kW processes up to 4.5 t/h tyre chips with an input size of about 50 to 80 mm in case of truck tyres and about 100 to 150 mm in case of car tyres to a granular size of 0.4 – 20 mm. The effective throughput of the press depends on the requested granular size of the final product. When producing rubber crumb of less than 4 mm, the capacity of a single-stage grinding system is about 2.5 t/h. The respective oversize particles are mixed with the tyre chips in the buffer bin upstream the granulation press and ground again.

Typical Separation Result

- Steel: 15 to 20 %
- Rubber crumb
  4 - 6 mm in size: 15 %
  2 - 4 mm in size: 15 %
  0 - 2 mm in size: 30 %
- Textile/rubber mixture: 15 to 20 %

Of course, the percentages can vary depending on the composition of the input material.

Conditioning of the Ground Product

After grinding, magnets separate the uncovered steel wires and steel/rubber compounds. In a first screening phase, fines smaller than 8 mm are separated and conveyed to the crumb cleaning system. The coarse fraction and the steel/rubber compounds are returned to the granulation press, the quantity of the returned material depending on the particle size spectrum of the requested product.

After granulation, the ground product is classified according to customer requirement and cleaned in fractions in a multi-stage sorting and sifting system. Metal separation is effected in magnetic drums, classification by means of screens. Final sifting for separation of textiles and minerals is realized by means of zigzag sifters and table separators. Depending on the requirements of the customer, the cleaned crumb can be packed in small or big bags. As alternative, it can also be stored in silos for bulk loading in tank trucks or containers.

The modular system is designed for a plant capacity of 2.5 t/h per granulation press in three-shift operation. This corresponds to a throughput of up to 15,000 t/a for one line. By mounting several modules in parallel, the plant capacity can be increased almost at random.

Wide Range of Application for Products

Apart from the high purity degree of the rubber crumb and meal, the process also excels by the very pure steel fraction obtained as final product. With a maximum residual impurity of three percent rubber and textiles in the steel, for the first time prices of clearly more than 100 Euro/t can be reached with the steel fraction. These high-quality steels are used in blast furnaces for steel production or recently as additional concrete reinforcement for the construction of buildings.

The rubber crumb obtained by warm grinding has a much larger specific surface than the cold-ground crumb. Rubber crumb and meal are used in different fields of application. They are used as filler in the caoutchouc industry, for example. Thus material costs can be reduced and the production process simplified. With the addition of PU binders, the material can also be pressed to protection mats for playgrounds and sport venues surfaces. Another possibility is the addition to topsoil which improves the compaction and drainage behaviour of heavily trampled lawns. When adding plastic crumb, such as recycled thermoplastics, instead of PU binders, elastomer compounds can be produced in special extrusion processes. By means of extrusion or injection moulding, a large number of products can be produced from these materials. Warm-ground rubber meal is particularly appropriate for this purpose.

When added to asphalt, the asphalt properties for road construction are improved, as the rubber asphalt reduces noise emissions by up to nine decibel. Besides, the temperature stability of the road surface increases, so that the formation of lane grooves in summer and frost cracks in winter is reduced.The application possibilities, particularly for warm-ground crumb, are numerous. But they are only efficient when using an economic granulation process.

Advantages of the Technology

- Compact construction size,
- reduced machine expenditure due to single-stage grinding,
- prolonged life granulation tools, thus wear costs of 5 Euro/t,
- high throughput,
- fast and simple tool change,
- automatic adjustment of the grinding gap by means of the hydraulic system,
- automatic lubrication,
- noise emission level below 85 dB(A),
- production costs of about 40 €/t.