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Alternative fuels: Quality management as a base for successful implementation and reliable substitution rates

Every cement producer in the world has implemented a sophisticated quality control system and management for its core cement products. As a mass product, several quality control procedures are implemented in order to supply a cement product that fulfils the needs of the clients. In this paper, Dirk Lechtenberg describes how quality management, starting at the quarry, can control a constant kiln feed, fuel additives and temperatures and ends with the shipping of the product.

Top: A RDF production plant.

Above: A RDF loading vessel.

Since the introduction of alternative fuels in the manufacture of cement, it has largely been the use of refused derived fuels (RDF) that has become common practice in the northern European cement industry, and has resulted in cement plants gathering a large amount of information and experience in the quality management of RDF. The name of RDF concludes the main issue – its waste. Waste always varies in its composition due to different sources, climate, even different seasons and national holidays. To succeed in the use of RDF as a suitable replacement for traditional fuels, a specialised quality control system is needed. The quality management of RDF has to start at the source: defining waste qualities and sourcing the right raw materials for the production of RDF. Since MVW Lechtenberg is in charge of the quality control and management, as well as marketing, of around 250,000t of RDF from well known German producers, this paper will give an insight into quality management systems for RDF.

Processing technologies in RDF production

The processing technologies for the production of RDF have given a lot of support in supplying a suitable RDF fraction- but if you put waste into your shredder- you only get shredded waste- not RDF.

As each kiln is different and each type of waste is different, there is no common specification for RDF available. A specification, based on the legal and technical requirements is the baseline for a successful quality management system for RDF.

In most developing countries – and even in well developed countries – there are no legal definitions for the co-incineration of wastes. Even within Europe there are different regulations for the use of RDF in the cement industry. There is no legal definition of the term 'Refuse Derived Fuel' and it is interpreted differently across countries. It should be noted that the terminology used in different countries to describe the material which is being co-combusted may reflect the desire of the users to have the material treated in a specific way under existing legislation.

Refuse is a general term for municipal solid and commercial wastes and in English speaking countries RDF usually refers to the segregated high calorific fraction of municipal solid waste (MSW), commercial or industrial process wastes. Other terms are also used for MSW derived fuels such as

- Recovered fuel (REF)
- Packaging derived fuels (PDF)
- Paper and plastic fraction (PPF)
- Process engineered fuel (PEF).

REF, PDF, PPF and PEF usually refer to a source-separated, processed, dry combustible MSW fraction (e.g. plastics and/or paper) which are too contaminated to be recycled. The terms 'secondary fuels, substitute fuels and substitute liquid fuels (SLF)' are used for processed industrial wastes which may be homogeneous or mixed to specification.

Examples of these fuels include:

- Waste tyres;
- Waste oils;
- Spent solvents;
- Bone meal;
- Animal fats;
- Sewage sludge;
- Industrial sludge (eg paint and paper sludge).

These terms can also refer to non-hazardous packaging or other residues from industrial or trade sources (eg plastic, paper and textiles), biomass (eg waste wood and sawdust), demolition waste or shredded combustible residues from scrap cars. Waste materials can be used as alternative fuels provided that they do not contain harmful substances. In particular, the presence of PCBs, chlorine, sulphur and heavy metals is either specifically precluded, or limited, in line with state or local regulations. For instance, the use of waste in incineration processes in Germany is controlled by specific requirements in the German Federal Emission Protection Law. Therefore, alternative fuels are only used in cement plants if their composition is in compliance with the relevant regulations. Table 1 shows such specifications.

The types of wastes which are suitable for alternative fuels production are listed in a 'positive list.' The following table shows the 'positive list.'

- Group I: Wood, paper, cardboard;
- Group II: Textiles, fibres;

- Group III: Plastics;
- Group IV: Other materials (waste paint, absorbents);
- Group V: High calorific fraction from mixed collected waste (C&D, MSW).

Besides this list, which is seen as a guideline for suitable wastes, the real emission values are more important. Each incineration facility has certain emission limits that need to be achieved by legal requirements. The most important piece of EC legislation with regards to RDF utilisation in industrial processes is the new Waste Incineration Directive (2000/76/EC), which aims to bring closer the requirements for incineration and co-incineration. This is going in the right direction to address the concern of environmentalists that industrial plants co-incinerating waste-derived fuels are not as strictly controlled as waste incinerators. The preamble to the directive clearly recognises both of these as desirable. The directive stated that the distinction between hazardous and non-hazardous waste is based principally on the properties of waste prior to incineration or co-incineration but not on differences in emissions. The same emission limit values should apply to the incineration or co-incineration of hazardous and non-hazardous waste but different techniques and conditions of incineration or co-incineration and different monitoring measures upon reception of waste should be retained.

The co-incineration of waste in plants not primarily intended to incinerate waste should not be allowed to cause higher emissions of polluting substances in that part of the exhaust gas volume resulting from such co-incineration than those permitted for dedicated incineration plants and should therefore be subject to appropriate limitations.

Besides the regulatory framework, which is defining the base specification for the use of RDF, the technical requirements have to be specified and controlled. Among others, these include:

- Grain size and particle distribution;
- Moisture content;
- Chlorine /alkaline content;
- Sulphur.

These depend on the feeding point, retention time, raw materials, current fossil fuels and other process related issues. According to the influence of RDF in clinker production, emissions, heat losses and clinker quality, this specification may need to be renewed in certain parameters.

Many cement plants around the world are using 'standard' specifications – which are available in online and offline formats – and some specify grain sizes of anything up to 15mm. Admittedly, the incineration behaviour of RDF in a very fine grain size is preferable but prohibits many projects because of very high processing costs.

Quality measures

A specification is good as long as it is fulfilled. Most cement plants have very highly sophisticated laboratory equipment to analyse mineral substances. Have you ever tried to grind a mixture of textile fibres, film and other compound materials in your laboratory mill? Don't try it. You will think about this when you try to clean your mill of melted plastics.

To obtain good and reliable quality management of RDF, in most cement plants some investments are needed for laboratory equipment for sample preparation, drying and analysis.

The analysis procedures and norms are well defined. It starts with the sampling. The sampling is done while or immediately after receiving. The samples are taken using 10 litre clean and dry buckets with lid. The label with sample information has to be on the bucket and not on the lid. The label has to include the following information:

- Date;
- Time;
- Name of person who takes the sample;
- Supplier;
- Material;
- Sample location;
- Car registration plate.

This must be written on adhesive labels in such a way that it cannot be rubbed off and the label cannot fall off. If a mixed sample cannot be produced by automatic division of the sample during feeding, it must be narrowed down by quartering the sample crosswise. In order to divide by quartering, the homogenised mixed sample must first be tipped out into a conical pile on a suitable work surface. Quartering this pile - e.g. dividing cross-

Parameter	Dimension	Maximum Values							
		Germany	Austria		Switzerland		Spain	Belgium	France
		*A	*A	*B	*C	*D			
Cadmium	mg/kg	9	27	2	5	2	100	70	-
Thalium	mg/kg	2	10	3	-	3	100	30	-
Mercury	mg/kg	1.2	2	0.5	5	0.5	10	5	10
Sum H+Cd+Tl	**mg/kg**	-	-	-	-	-	**100**	-	**100**
Arsenic	mg/kg	13	15	15		15	-	200	-
Cobalt	mg/kg	12	100	20	60	20	-	200	-
Nickel	mg/kg	100	200	100	80	100	-	1000	-
Lead	mg/kg	400	500	200	500	200	-	1000	-
Chromium	mg/kg	250	300	100	500	100	-	1000	-
Copper	mg/kg	700	500	100	600	100	-	100	-
Antimony	mg/kg	120	20	5	800	5	-	200	-
Sum Sb + As + Co + Ni + Pb + Sn + V + Cr	**mg/kg**	-	-	-	-	-	**5000**	**2500**	**2500**
Manganese	mg/kg	-	300	-	-	-	-	2000	-
Vanadium	mg/kg	25	-	100	-	100	-	1000	-
Tin	mg/kg	70	70	10	-	10	-	-	-
Beryllium	mg/kg	2	-	5	-	5	-	50	-
Selenium	mg/kg	-	-	-	-	-	-	50	-
Tellurium	mg/kg	-	-	-	-	-	-	50	-
Zinc	mg/kg	-	-	400	-	400	-	5000	-
PCB	mg/kg	-	-	-	-	-	30	30	25
Halogens (exp as Cl)	%	-	-	-	-	-	2	2	2
F	%	-	-	-	-	-	0.2	-	-
Sulphur	%	-	-	-	-	-	3	3	3

Table 1 (above): Limit values in different permits and regulations in European countries for alternative fuels.
*A = Plastic, textiles, wood etc high calorific fraction from common waste.
*B = General combustible waste (CV 25MJ/kg)
*C = Other wastes for disposal (CV 18MJ/kg)
*D = Other wastes for disposal

Parameter	Unit	AT	BE	DK	FI	FR	DE	GR	IT	LU	NL	PO	ES	SE
Particulate	Mg/Nm^3	20-34	34-50	40	50a-50b	35-50	15-25	30	50	50	30	77	30	50-150
		Daily/ha if hourly	Daily	Daily			Daily	100% half hourly	-	Half hourly	100% half hourly	Daily	Half hourly	Monthly
TOC	Mg/Nm^3	50 (10 by 2002)	49-75	20	-	20	-	20	5/ 20/ 150/ 300/ 600	30	40	50	20	20
		Daily/ha if-hourly	Daily	Annual		Half hourly		100% half hourly		Half hourly	Half hourly	Daily	Half hourly	3 hour av.
HF	Mg/Nm^3	0.7	3-0	2		4	1	4	5	5	1	1	4	0.2
SO_2	Mg/Nm^3	140/400	600-1000	300	150-400	1280	<400	200	600	100	90kg/hr	1300	200	200/1700
		Daily/ha if-hourly	Daily	Annual	Monthly	Half hourly	Daily	100% half	-	Half hourly	10 day av.	Daily	Half hourly	20 month av.
NO_2	Mg/Nm^3	500/800	1000-1800	-	1200-1800	1200	<800	-	1800	1600	2600	1300	300ppm	400-1600
		Daily/ha if hourly	Daily		Monthly	Daily	Daily	100% half	-	100% half	100% half	Daily	Daily	Monthly
Cd-Tl	Mg/Nm^3	0.05/0.05	0.1-0.2/ 0.1-0.2	0.2/-	-	0.05	0.05	0.05	-	0.2/0.2	0.05/0.05	0.1	0.05/0.05	0.0002/ 0.006
		30min-8 hour av.	Daily	Annual	-	30min-8 hour av.	Daily	30min - 8 hour av.	-	Half hourly	Half hourly	Daily	-	3 hour av
Hg	Mg/Nm^3	0.05	0.1-0.2	0.2	-	0.05	0.05	0.05	-	0.2	0.05	0.1	0.05	0.001
		30min - 8 hour av	Daily	Annual	-	30min- 8 hour av	Daily	30min - 8 hour av	-	Half hourly	Half hourly	Daily		3 hour av.
Dioxin/Furan	Ng/m^3 TEQ	0.1	0.1	-	-	0.1	0.05	0.1	10,000	0.1	0.1	0.1	0.1	0.1

Parameter	Dimension	Practical value	Maximum value
Arsenic (AS)	mg/kg (dry)	5	13
Beryllium (Be)	mg/kg (dry)	0.5	2
Cadmium (Cd)	mg/kg (dry)	4	9
Cobalt (Co)	mg/kg (dry)	6	12
Chromium (Cr)	mg/kg (dry)	40	120
Copper (Cu)	mg/kg (dry)	120	300
Mercury (Hg)	mg/kg (dry)	0.6	1.2
Nickel (Ni)	mg/kg (dry)	25	50
Manganese (Mn)	mg/kg (dry)	50	100
Lead (Pb)	mg/kg (dry)	70	200
Antimony (Sb)	mg/kg (dry)	25	60
Tin (Sn)	mg/kg (dry)	30	70
Thallium (Tl)	mg/kg (dry)	1	2
Tellurium (Te)	mg/kg (dry)	3	5
Selenium (Se)	mg/kg (dry)	3	5
Vanadium	mg/kg (dry)	10	25

Table 2 (top): Table of emission limits.

Table 3 (above): Requirements regarding minor elements following the regulations/guidelines given in RAL-GZ 724.

Upper right: Analysts supervise the sampling of RDF, ensuring that elements within the fuels fit within specified limits.

wise and disposing of the opposing remnants - serves to reduce the material until the required sample quantity of 20l remains. Half of this sample (10l) is sent off as a laboratory specimen, the other half is stored as a reference sample. A procedure for reducing the mixed sample adapted to the monitoring modalities and the prevailing operating conditions has to be developed.

Table 3, left, shows the requirements regarding minor elements following the regulations/guidelines given in RAL-GZ 724. From this point on, the RDF has to comply with the practical value, which is the median of a sample analysis series, and the analysis results must not exceed the maximum values. The median value will avoid problems with limit values (eg a copper paper clip in the sample).

A typical sampling frequency depends on the type of RDF. If the input waste of the RDF production plant is well known (eg regular industrial wastes), an analysis only has to be carried out every 500t, as long as the supplier continues with a reliable fuel quality. For production reasons, continuous monitoring is advised, but until now it has not been made available online. Therefore, an analysing time (including preparation) of 24 hours for minor constituents is standard.

But what happens if the quality of the RDF does not meet the required standards? Most RDF production plants have not yet introduced the 'cement philosophy.' They cannot understand that RDF can have a big influence on the clinker production process and will not understand until they are directly related to the success – or failure – of an RDF substitution. In layman's terms: if they do not deliver the right quality they have to pay.

A steady and continuous supply of a defined quality of RDF is the base for a high substitution rate of RDF to reduce fossil fuel consumption with minor impact on the clinker production process. To secure these standards, MVW Lechtenberg always suggests an attachment in the purchase and delivery contract for RDF of so-called 'bonus/malus regulations' for certain quality parameters.

The supplier guarantees the particular net calorific value and chlorine level according to the quality requirements described in Annex I. The supplier then agrees with the customer to pay a fine if the quality requirements are not ensured.

The fine is calculated according to the following scheme. The bases are the samples taken and analysed by the customer from the deliveries. The average of the single analysis results for net calorific value and chlorine over a delivery period of three months is then calculated. The average values are compared during the reception inspection with the values shown in Tables 1 and 2. If the given values of the receiving inspection exceed or fall short of the required values in the specification, the bonus/malus regulations applies.

Summary

The successful use of RDF as substitute fuel in the cement industry is driven by a steady and continuous supply of high quality RDF. In order to secure an environmentally friendly and economic substitution, quality control and management is key.