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Diagnostic methods into the Corrosion Potential of Alternative Fuels i.e. Biomass and Refuse Derived Fuels

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ABSTRACT

The substitution of fossil fuels through alternative fuels (i.e. refuse derived fuel, biomass) is of great interest not only for the environmentally aspect but also for the economic aspect. Simultaneously from an ecological and economic view it is necessary to attain high energy efficiency and availability, but that is limited to the properties (burnout behaviour, slagging and corrosion potential, energy density) of these alternative fuels. In comparison to the traditional fossil fuels like coal, these alternative fuels can be classified as so called difficult fuels. Therefore it is essential to know information about behavior of these fuels i.e. reaction technical properties. It is thus possible to limit and assess corrosion risks in advance, and hence through the prevention / reduction of corrosion – a high energy efficiency and plant availability can be attained.

With the use of biomass fuels and refuse derived fuels (RDF) in mono-combustion facilities and co-firing facilities several problems may occur. Mostly the efficiency is affected by the decrease in operational availability of the facility due to slag formation and corrosion. For the application in large operational plants, it is necessary to develop and establish appropriate methods for investigating fuel characteristics (ignition and burnout behaviour, slag formation and corrosion potential) in laboratory scale facilities and pilot plants.

In the assessment of corrosion effects, the first and most accurate step involves the corrosion diagnosis of plant components during maintenance shutdowns but that is rather at a late stage. Secondly the diagnosis can be carried out during plant operations through the methods like "ASP"; "Online-Heat Flux Measurement" and "Online-Balancing".

In this paper the main objective is the determination of the behaviour of fuels (technical characteristics) and the ability to diagnose the corrosion potential of fuels before their application in large plants. Additionally the incorporation of the above mentioned methods of diagnosis during plant operations will be discussed. With such a concept in mind, broader and effective information can be derived into fouling layer formation and corrosion potential, in respect to the used fuel (e.g. RDF, Biomass).

Keywords: *difficult fuels, method, fouling layer probe, slag formation, corrosion, fouling layer formation*

1. INTRODUCTION

Important for the use of alternative fuels in view of the reduction of the $CO_{2,(fossil)}$ – emissions and resource conservation is the choice and optimization of the respective process. That requires a detailed knowledge of the alternative fuels (Biomass and Refuse derived fuels (RDF)) and their relationship to the respective process.

The energy efficiency and the availability of biomass- and RDF – power plants is limited by the strong fouling layer formation on the heat exchanger surfaces and the resultant corrosion on the steam generator tubes.

Due to this reason it is important to limit and assess the corrosion risks. Hence the reduction / prevention of corrosion - an increase in the energy efficiency and plant availability can be attained.

The evaluation of the used fuel in view of the fouling layer formation and corrosion potential (before and after application) presents an important requirement for the plant operators and designers. For the design of new plants and the operation of existing plants – the information, about the substitution of fossil fuels with biomass or RDF - is currently not or insufficently available.

The corrosion potential is determined through the solid, liquid and gaseous components – which settle on the colder heat exchanger surfaces (mechanical and through condensation). From this point the corrosive effect can start. For the evaluation of the corrosive effect of these components, of crucial importance is the knowledge about the respective precursor substances (e.g. alkali chlorides, heavy metals etc).

In real plant operations, the sub – steps of the releasal of corrosive substances about the deposition on the tube walls / tubes up to the oxidation of the material of the heat exchanger - are influenced by a multitude of parameters.

These parameters cannot be ascertained through conventional laboratory investigations (Elementary and immediate analysis etc) - but they must be investigated under real process conditions. From that e.g. Fouling layer probe [1] is available and therefore the deposition forming components in the flue gas can be evaluated. The results of the measurements enable a statement to be made about the deposit formation and corrosion potential. Therefore it is necessary to carry out extensive investigations with different parameters in relation to the used fuels and the process conditions.

These parameter variations (e.g. fuel change, load changes, process operation etc) are in the required extent in real process operation not practicable and respectively the operation of these investigations is very costly and timely intensive.

Through a better knowledge about the deposit layer formation and corrosion potential, an increase in the energy efficiency and the reduction of the damage prevention potential can be achieved.

From this reason it is necessary to develop a method, in which an assessment of the deposit layer and corrosion potential prior to application in real plants can be done.

In the following paper, information about the so-called „Diagnosis on the Fuel“ will be presented. It is based on the deposition layer measurement, however not in real plant application scale, but in a test facility plant, in which specific (close to reality) process parameters can be adjusted, which lead to the above named parameter variation.

2. Influential-parameters on corrosion and the possibilities of diagnosis

The important influential parameters on the corrosion potential are the corrosion relevant components

- in the fuel and
- the dependency of the influential parameters of the combustion process:
  - the released solid, liquid and the gaseous components in flue gas and
  - the formed deposits on the heat exchanger hot surfaces.

From material point of view there is a broad field of corrosion relevant elements, exemplary to note are the different corrosion effects of chlorine and sulphur compound, which depend on the temperature and the change of the aggregate state between solid – liquid and the gaseous state. Exemplary the total chlorine content is insufficient as a quality criterion for the refuse derived fuels and biomass.

The chlorine bonding form for the release and deposit formation plays an important role.

Important in complex reactions and phase transitions are chlorine and the group of alkali elements, which are naturally bound in biomass (potassium e.g. is responsible for wood growth as a nutrient). Additionally, the heavy metals found in high concentrations in refuse derived fuels from waste, have also to be considered.

On the flue gas side, the high load of HCl can be evaluated as negative. However the distribution of chlorine in the fuel in both partial streams - HCl and chloridic salts are very much dependent on the operational conditions and the limits can fluctuate.

Decisive for the corrosion potential is whether the HCl is carried out with the flue gas or it reacts with the mentioned alkali and heavy metal compounds, which lead to salt deposition.

High fractions of SO_2 and/or SO_3 are evaluated as positive [2]. SO_2 and especially SO_3 are considered as active reaction partners in comparison to the dissolved or crystallized chlorine. It results in the sulphatisation of the species in flue gas and has a mild influence as corrosion relevant [3]. In practical applications, this relation is uncertain in the combustion of difficult fuels, - possibly limited by kinetic constraints.

Corrosions occurrence is not only from the composition of the fuel influenced, but from the real conditions in the plant, which enable the release and the deposition of the corrosion relevant components from the fuel. Thereby the combustion firing technology used and the respective process operation play a decisive roll.

From the view of corrosion important are – the material composition of the fuel and flue gas (e.g. online measured or balanced with the aid of an online-balancing program [4] the temperature of the flue gas, the place specific temperature of the walls and their timely changes.

The characteristics of chlorine and sulphate salts, also their aggregate condition (gaseous, liquid, solid) and the partial pressure in the ambient gas room at liquid/solid state are related to the temperature of the considered place.

When the chloridic salts have a direct contact to the tube material there is a possibility of salt melt corrosion. If there is no direct contact to the tube material then the vaporized fraction of the salt has an effect, which leads to the conversion of iron into iron chloride and consequently that can lead to dynamic corrosion ([5], [6], [7]).

The corrosion mechanisms are linked to solid (or liquid) chloridic salts. Due to the material composition of alternative fuel the relevant components are potassium-, sodium-, zinc- and lead-chloride.

By the thermal application of alternative fuels the hot flue gas can carry the gaseous chloridic salts in high amounts. On the path through the heat exchangers the hot gas is cooled, in which the gaseous choridic salts, depending on the saturation concentration and the temperature, can be converted into liquid/solid particles – likely to deposit and take part in the deposition layer formation. Depending on the load of chloridic salts (concentration) the temperature in which the salts can be converted into liquid/solid particles varies from 800°C for sodium chloride up to about 300°C for zinc chloride. The temperature of the pure salt lies always higher than the temperature of the mixture salts (multi component mixture), which can also comprise the sulfatic salts.

As described not only the temperature on the path through the heat exchangers, but also the temperature on the surface of the wall or tube and the temperature on the surface of the fouling layer place are important.

The temperature gradient in the solid system (from the surface of the fouling layer to the inner tube wall) changes due to the changing temperature differences of both steam generator medium (flues gas and water i.e. steam). This is through the different released heat amounts from usually heterogeneous alternative fuels

- in relation to the calorific value fluctuations from the fluctuating elementary compositions and
- different moisture amounts.

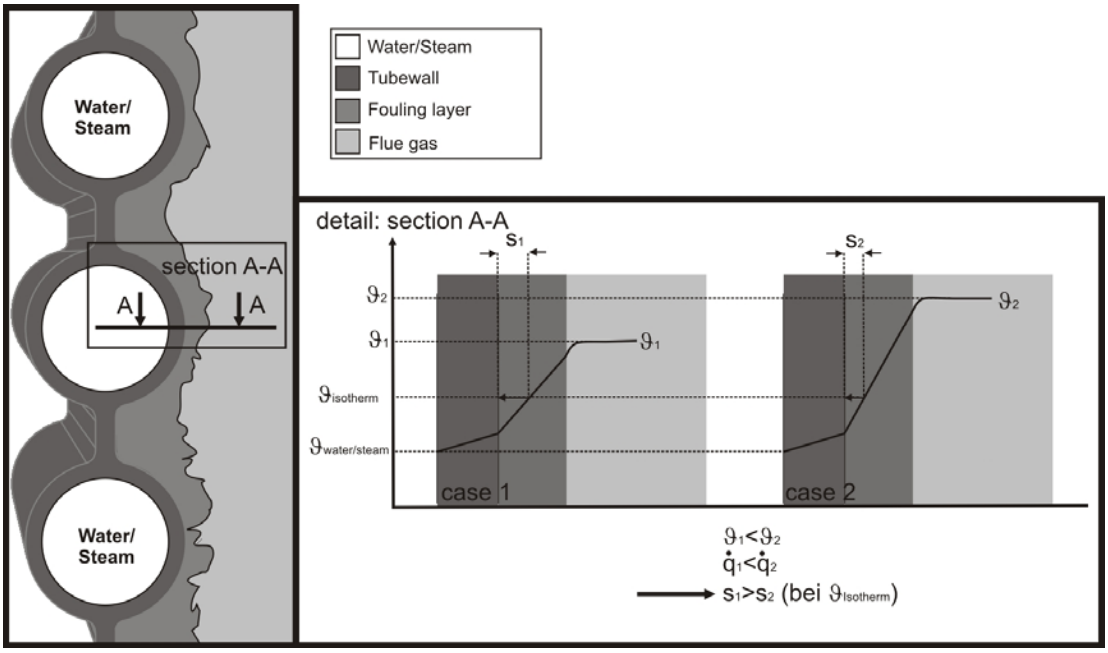

Figure 1: Temperature profile of the tubewall at different flue gas temperatures $\vartheta_1 < \vartheta_2$.

If during the combustion of the fuel a lot of heat is produced, therefore generally the temperature on the surface of the tube wall (flue gas side) increases i.e. on deposition layer, and if lower heat amount is released then the surface temperature is reduced. Simultaneously that means the temperature gradient for the solid systems (fouling layer surface to inner tube wall), is constantly changing – due to the poor heat transfer coefficient [8] from the formed layers (in comparison to the tube material). From a steep temperature gradient in solid systems (a lot of heat is released), the temperature gradient in the direction of the tube wall increases (see Figure 1; at $\vartheta_{Isotherm}$ is $s_1 > s_2$). This can lead to renewed mobility of the deposited solid salts in the direction of the tube wall through a repeated fusion and can build a layer of mono-mineral salt mixtures near the tube wall and an increase in the corrosion potential. Furthermore this results in the compaction of the deposition [9].

The temperature gradients in solid systems are dependent on the heat flux density. With the help of heat flux measurement sensors ([10] and [11]), fitted on the membrane wall, the heat flux density can be evaluated. The information collected from the industry up to this time, shows that the corrosion potential increases with increasing heat flux density [9]. Further statement about the deposition layer formation and the characteristic of the deposit (e.g. heat transfer coefficient [8]) are however important, to support this thesis i.e. this can lead to deeper understanding of the corrosion mechanisms. For the investigations into the corrosion behavior of fuels in the respective plants –therefore required are detailed investigations on:

- the combustion process,
- the flue gas,
- the carried or formed particles in the flue gas and
- the formed deposits.

From operational plant point of view it is necessary to develop methods for the evaluation of the deposition- and corrosion potential. The current possibilities for corrosion diagnosis in industrial plants:

- through continuous monitoring during plant shutdowns (e.g. fouling layer sampling etc.) and
- during plant operation, with the aid of sensors (fouling layer probe and heat flux sensors) to evaluate the particles which participate in the fouling layer formation,

shows that through the combination of these diagnosis methods it is possible to deduct an evaluation criteria for the fouling layer formation and the corrosion potential.

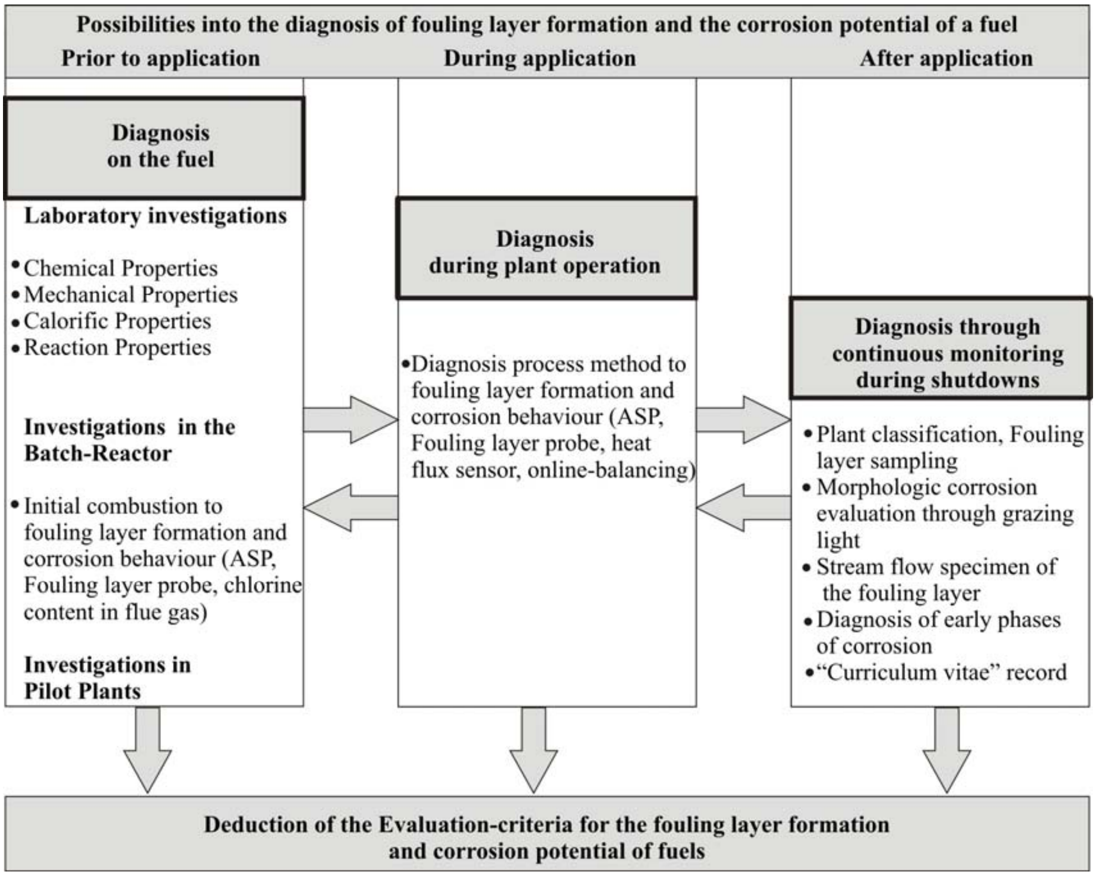

Figure 2: Possibilities into the diagnosis of fouling layer formation and the corrosion potential.

An extension to these possibilities is the – diagnosis on the fuel (Figure 2). With the aid of this statement about the deposit layer formation and corrosion potential before application in industrial plants, the risks of corrosion damage can be limited.
In the following the diagnosis on the fuel, with which the deposit formation components in the flue gas can be evaluated, will be described.

3. Method of the „Diagnosis on the fuel“

Fundamentally there exists the possibility to carry out an analysis of technical characteristics of fuels and a diagnosis of the fouling layer formation and corrosion prior, during and after the application of the fuel in the respective plants (Figure 2).One can broadly differentiate the procedure:

- Diagnosis on the fuel
- Diagnosis during plant operation
- Diagnosis through continuous monitoring during shutdowns.

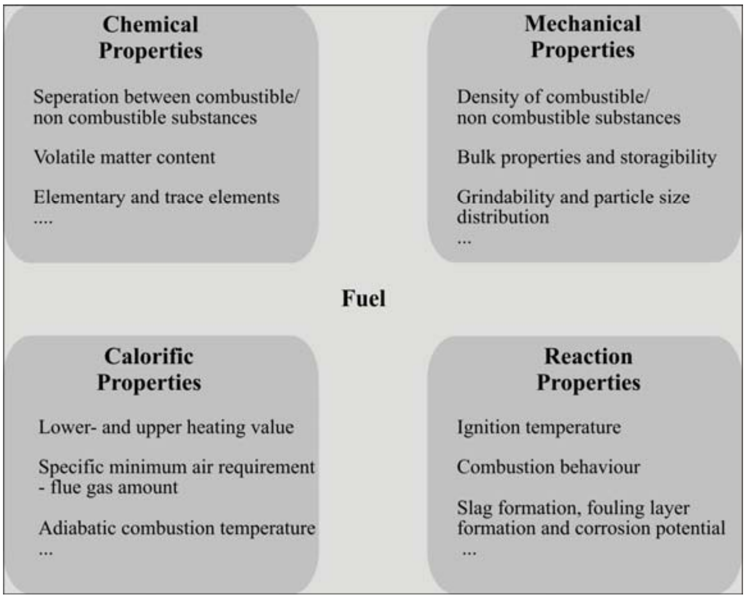

Figure 3: Fuel properties.

The easiest but also the most accurate possibility to evaluate the fouling layer formation and corrosion potential is after application of the fuel in the plant during a shutdown. An early detection of the negative influences of the plant or the suitability of the fuel for the respective plants is with the aid of this method not possible. The effects can only be attained through gathered positive or negative experiences of the applied fuel.
Whereas the laboratory investigation is generally accepted and in any case can be carried out – before application of the fuel in a plant. First investigations to the chemical, mechanical and calorific properties (Figure 3) can be done – very fast and without any damage in industrial plants. For the laboratory investigations there are many papers that have been published ([12], [13]) e.g. hence that would not be further discussed. Only in view of the question of the accuracy of the presented prognosis, based on the composition of the fuel, it should be considered that the corrosion behavior is not only influenced by the chemical, calorific, mechanical properties, but also through the reaction technical properties (process technical conditions, process control, operational and constructive parameters). These reaction technical properties can be determined only under real process conditions (test facilities, pilot and real plants).

For the investigations of the deposition layer components for the diagnosis during plant operation, there exists the possibility to apply the developed method from the company CheMin GmbH (Augsburg, Germany) for industrial plants. These are the tested sensory processes ASP (Ash to Salt Proportion), deposition layer monitor and deposition layer probe. Currently this process is used in the diagnosis of operation in industrial plants.

These processes have the ability to model the deposition layer formation. The information about the chemical-mineral milieu parameters of the formed deposition layer on the probe can be evaluated by the location resolved analysis process (Raster Electron Microscope (REM) in connection with Energy Dispersive X-ray spectroscopy (EDX). The iso-kinetic sampling of the flues gas particles (process identification code: ASP, Ash- Salt-Proportion) produces an image of the flue gas transported load from solid and de-sublimated materials, and also the proportions within each other in relation to the interaction between the fuel and combustion firing unit. This information can therefore e.g. in the ASP-Diagram [1] graded and is relevant for the evaluation of the corrosion potential.

The deposition layer probe and also the deposition layer monitor are applied in different temperature zones, such that the location resolved sampling along the entire boiler is possible.

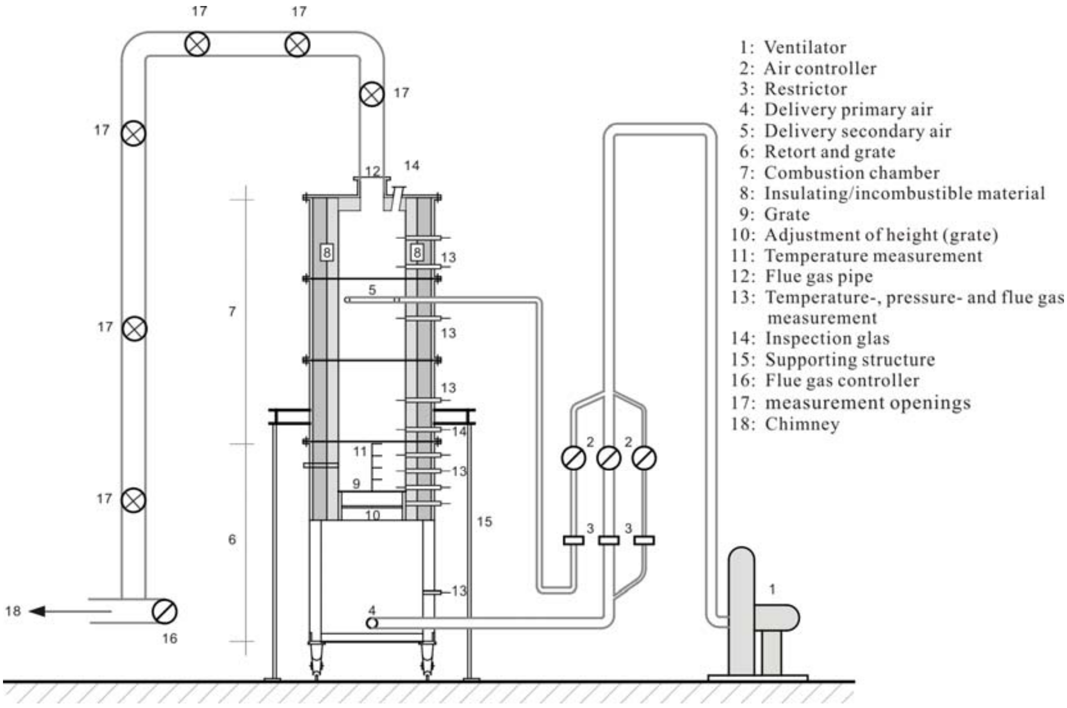

Figure 4: Constructional layout of the Batch-Reactor.

These investigations can be carried out also in the test facility plant e.g. the so called Batch-Reactor (Figure 4). The Batch-Reactor [14] is suitable for the characterization of fuels. A comparison of the experimental results in reference to the burnout behavior of the fuel was carried out in the mentioned Batch-Reactor in an earlier project. In this project [15] cooperative tests using wood chips were carried out in three differently constructed Batch-Reactors under the same conditions (fuel, air supply, temperature of the combustion chambers) and a good correlation between the experimental results was observed.

In relation to the applied fuel – parameter variations (e.g. air grading, air preheating etc) with the aid of the batch reactor can be carried out for specifically targeted process settings. The implementation of these investigations in comparison to the costs and time intensiveness of investigations in real plants are much lower and generate no problems in the real industrial plant. In view of the fast timely availability of the evaluated data, in dependency to the wide number of the applied parameter variations in the Batch-Reactor – the possibility of determining the deposition layer components must be carried out, and hence a statement about the evaluation of the fuels can be made in view of the deposition layer formation and the corrosion potential. This method is identified from the authors as *Diagnosis on the Fuel* (see also Figure 2).

In testing this method investigations must be are carried out, in which the evaluation of data – before application (in a Batch-Reactor) and – during application (in a real industrial plant) and are comparable to each other. In one way, it is possible to prove the real process depiction in the Batch-Reactor and in another way to compare the measured data with the aid of sensors and to evaluate the interdependencies of this method to other applied methods (heat flux measurements).

As earlier mentioned, the hot flue gas in real industrial plants cools down as it flows through the steam generator, in which the gaseous forming chloridic salts, depending on the saturation concentration and temperature in change into liquids or solid particles and can participate in the deposition layer formation. In the Batch-Reactor there are measurement openings along the flue gas path, which allow the measurements in the same temperature zone (approx. 800 °C to 200 °C) similar to the measurements in real industrial plants - and hence the measurements are comparable i.e. the measured deposition layer components.

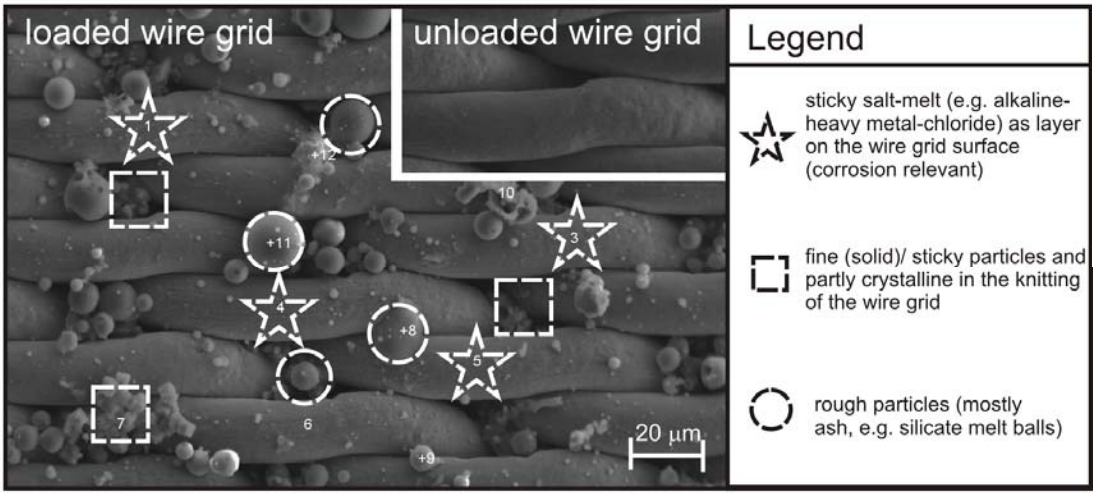

Figure 5: REM picture of a loaded and unloaded wire grid and the apportionment of the particles for the deposition layer measurements.

With the aid of the deposition layer probe, the deposition layer participative substances can be evaluated. The tempered probe is placed in the flue gas path, in which through a wire grid iso-kinetically part of the flue gas is extracted by suction. The particles in the flue gas (solid and liquid) settle on the wire grid (see Figure 5). Through an analysis of the particles on a wire grid with the aid of Raster Electron Microscope (REM) the particles can be classified as rough and fine and also as solid or sublimate particles. Through the point i.e. planimetry measurements and with the aid of the EDX the quantitative and qualitative composition of a particle can be determined. A comparison of these measurements in different temperature zones allows the enriched or depleted defined substances (primarily the corrosion relevant) location specific to be evaluated [16].

Further knowledge about the deposition layer formation and corrosion potential - can be attained with the aid of the mentioned method through investigations of various fuels (with different corrosion potentials). Hence comparable fuel specific statements can be derived in relation to the respective application plant. In Table 1 there is a choice of different fuels (anthracite coal, wood chips, refuse derived fuel from industrial waste and cellulose pellets) and these were evaluated in the laboratory for their specific properties – such that a wide range of properties of the alternative fuels can be presented. In the following section a short emphasis about the characteristic differences between fuels will be addressed:

- Based on the different elementary analysis it results in a wide range of calorific values from anthracite coal with approx. 27 MJ/kg to wood and cellulose pellets with approx. 15 MJ/kg.
- In view of the ash analysis the main component in anthracite coal is the silicon content and in wood pellets it is the calcium content. For wood pellets a high amount of potassium can be noted. The ash of cellulose pellets has a high content of sodium, which negatively influences the Ash-Fusion behavior (very low melting point).
- The refuse derived fuel from waste is characterized by the high chlorine content that is positive for the volatility of the heavy metals, which are found in the ash in high concentrations and that indicate a high corrosion potential.

With the aid of the diagnosis on the fuel information about the evaluation of the ignition and burnout behavior (depending on process settings) can be ascertained. Additionally further information can be attained with the aid of the deposition layer probe measurement on layer formation participative components (volatile corrosion relevant) from the fuel bed.

Depending on their chemical composition and the respective aggregate state („eutectic melting“ – visible on the wire grid) it is possible to make an statement about the corrosion potential of the deposition layer participative particles. Initial results of the deposition layer probe measurement in the Batch-Reactor in comparison to the measurements in real industrial operation will be presented and discussed in the following section.

Table 1: Laboratory investigations of different fuels.

description				**Anthracite coal**	**Wood pellets**	**RDF**	**Cellulose-pellets**
additional description						industrial waste	Residual material
Application area				Fluidised bed	Fluidised bed	rotary kiln, power plant	grate furnance
			Units				
1. Chemical properties							
moisture	w	raw	Ma.-%	9,81	4,28	12,50	5,27
ash	a	wf	Ma.-%	12,07	0,31	12,95	9,53
carbon	c	wf	Ma.-%	76,9	47,8	54,56	44,20
hydrogen	h	wf	Ma.-%	4,04	5,77	7,44	5,80
oxygen	o	wf	Ma.-%	4,29	45,5	35,61	49,96
nitrogen	n	wf	Ma.-%	1,8	0,49	1,96	0,01
sulphur	s	wf	Ma.-%	0,76		0,43	0,03
chlorine	cl	wf	Ma.-%	0,14	0,13	1,07	0,008
volatile matter	fl	roh	Ma.-%	n.b.	n.b.	75,45	n.b.
Trace elements							
aluminium oxide	Al_2O_3	wf	Ma.-%	n.b.	n.b.	7,54	0,20
sodium oxide	Na_2O	wf	Ma.-%	1,33	0,59	0,55	53,20
potassium oxide	K_2O	wf	Ma.-%	2,07	25,75	0,97	0,13
calcium oxide	CaO	wf	Ma.-%	4,94	44,1	30,71	0,60
iron oxide	Fe_2O_3	wf	Ma.-%	4,68	2,02	4,71	0,07
magnesium oxide	MgO	wf	Ma.-%	1,01	8,84	2,37	0,06
phosphorus oxide	P_2O_5	wf	Ma.-%	n.b.	n.b.	n.b.	0,64
silicon oxide	SiO_2	wf	Ma.-%	47,1	4,73	17,42	0,00
heavy-metals (in ash)							
cadmium	Cd	wf	mg/kg	n.b.	n.b.	2	0,186
thallium	Tl	wf	mg/kg	n.b.	n.b.	<0,2	n.b.
mercury	Hg	wf	mg/kg	n.b.	n.b.	0,2	<0,03
arsenic	As	wf	mg/kg	n.b.	n.b.	<2	3,63
cobalt	Co	wf	mg/kg	n.b.	n.b.	7	<1
nickel	Ni	wf	mg/kg	n.b.	n.b.	50	37,5
Selen	Se	wf	mg/kg	n.b.	n.b.	<10	n.b.
selenium	Te	wf	mg/kg	n.b.	n.b.	<10	n.b.
antimony	Sb	wf	mg/kg	n.b.	n.b.	39	16,15
lead	Pb	wf	mg/kg	n.b.	n.b.	140	6,38
chromium	Cr	wf	mg/kg	n.b.	n.b.	260	23,5
copper	Cu	wf	mg/kg	n.b.	n.b.	730	13,9
manganese	Mn	wf	mg/kg	n.b.	n.b.	130	39,5
vanadium	V	wf	mg/kg	n.b.	n.b.	8	9,7
tin	Sn	wf	mg/kg	n.b.	n.b.	<10	n.b.
zinc	Zn	wf	mg/kg	n.b.	n.b.	n.b.	299,9
beryllium	Be	wf	mg/kg	n.b.	n.b.	<0,2	n.b.
ash melting behaviour							
softening temperature			°C	>1300	>1300	937	700
hemisphere temperature			°C	>1300	>1300	1197	800
flow temperature			°C	>1300	>1300	1255	825
2. Mechanical properties							
max. particle size			mm	20	25	30	25
supply form/ bulk density							
dust							
kgranular				X		X	
pellet					X		X
bulk density			kg/m³	850	650	150	670
3. Calorific properties							
calorific value		raw	MJ/kg	26,62	17,77	21,98	14,77
		wf	MJ/kg	29,78	18,8	25,47	15,77

4. RESULTS

The presented results are from investigations in a circular fluidized bed plant, in which the effect of substitution of fossil fuels (anthracite coal) through biomass fuel (wood pellets) was investigated.

For the investigation of chemical, calorific and mechanical characteristics in the first step laboratory investigations were carried out, whereby the initial orientation values and a comparison of the fuel characteristics is possible (see Table 1).

Laboratory analysis is as first step to fuel characterization important, e.g. such that the biomass fuel requirement for the substitution can be investigated. Since the firing thermal capacity must be constant regardless of the substitution of fossil anthracite coal (reduction of the mass flow), then theoretically the determined calorific value (from laboratory) of applied mass flow of both fuels can be calculated.

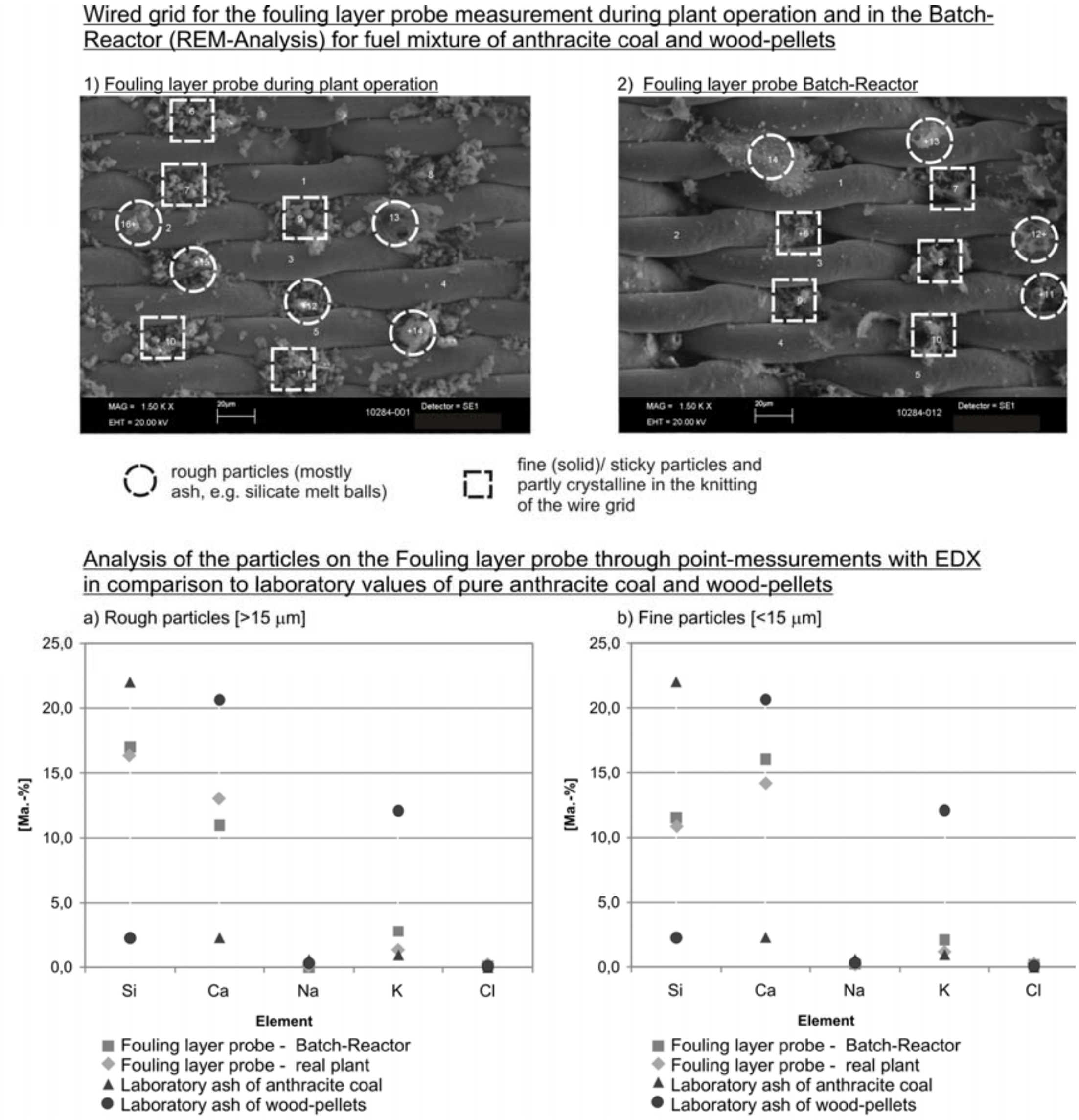

Figure 6: Laboratory investigations of various fuels

Based on the laboratory technical results only the iso-kinetic testing in the batch reactor and in the circular fluidized bed plant (during plant operation) can be addressed. In addition the deposition layer probe measurements were carried out in both plants. The test indicated identical and similar temperature behavior (ca. 300°C), such that the initial results from the Batch-Reactor could be compared with the results in circular fluidized bed plant.

Optically the differences of deposited particles on both probes are recognizable, not only the load but also the size of the particles. The structure of the particles on the contrary is very similar. In most cases they are rough to fine solid particles.

The differences are partly due the fact that the deposition layer probe measurements were carried out in the Batch-Reactor with a fuel mixture of 50 % anthracite coal and 50 % wood pellets and in the circular fixed bed with a fuel mixture of 65 % anthracite coal and 35 % wood pellets, based on firing thermal capacity.

Based on the sedimentation structure on the wire grid – the chemical data of the deposited particles was investigated with point- and small area measurements through the use of an EDX. In Figure 6 the comparison of the measurements – Batch-Reactor and in real plant (circular fluidized bed) for silicon, calcium, sodium, potassium and chlorine is shown. Furthermore the ash-elements of anthracite coal and wood-pellets analyzed in laboratory are also shown in the diagram. The chemical data from point- and small area measurements of the deposited particles from the deposition layer measurements in the Batch-Reactor and in practical operation (circular fixed bed plant) correlate quite well with each other.

Furthermore as expected, these lie between the laboratory analyses (ash) of the single fuels. The good correlation of the measurements in the Batch-Reactor, in comparison to the values of the real industrial plant, show that with the aid of a Batch-Reactor - it is realistic to make a diagnosis on the fuel for the deposition layer formation and the corrosion potential before application in a plant.

5. SUMMARY

The consideration of fuels only by laboratory analysis in view of deposit layer formation and corrosion potential is not conclusive.

The fuel is applied in a technical combustion unit and is influenced by the corresponding process conditions. It is then converted from a fuel to flue gas in relation to the respective operational control plant parameters.

For example, alkaline- and heavy metals and halogen compounds can be formed in different compositions depending on the process conditions. Relevant for the deposition layer formation and corrosion potential are only the definite conditions, which at respective concentration and steam pressure by the prevailing temperature on the hot surfaces - effect the deposition formation.

The process conditions from technical combustion units can be modeled closely in test facilities and pilot plants.

From the sampling of the flue gas along the flue gas paths (cooling) information about the elements and compounds can be attained and thus an assessment in view of the deposit layer formation and corrosion potential can be determined. In this paper a method was presented, in which fuel (in kilogram range) was combusted in a Batch-Reactor under realistic process conditions and through the use of a deposition layer probe- particles (rough, fine, solid and partly liquid) were collected from the flue gas path. The mineralogical and chemical analyses of these particles provide a statement about the deposit layer formation and corrosion potential.

In this case, it is a question about the transference of the real industrial plants already proved ASP-Investigations to pilot and test facility plants – with the aim to assess fuels before their application in real industrial plants.

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