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Camera Measurements in Cement Kilns – Impact of Alternative Fuels on Kiln Flames

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Introduction

Alternative fuels are increasingly used in the cement industry to reduce production cost. In addition, the use of waste derived fuels may reduce the need for landfilling and biogenic fuels can reduce the net CO_2 emissions from the industry [1]–[3]. One type of commonly used alternative fuel is Solid Recovered Fuel (SRF), which is produced by mechanical treatment of non-hazardous industrial or household waste. This fuel consists of mainly plastics, paper and cardboard, as well as incombustibles such as glass and metals [4], [5]. SRF is characterized by a low heating value, high moisture content, and a large particle size compared to conventional fossil fuels such as coal or petcoke. This may lead to some problems in the cement production process, such as lower combustion temperature and particles burning in contact with the cement clinker, resulting in a decreased clinker quality [6]–[8].

In order to study the effect that SRF has on the flame in the cement kiln a special camera probe was developed. It was manufactured to tolerate temperatures above 1000 °C, so it can be inserted in the cement kiln hood next to the burner, as shown in Fig 1. This allows for detailed visual observations of the near burner zone to study e.g. ignition point and fuel flow. The camera was used at three different cement plants, which co-fire solid fossil fuels with SRF. The impact of adding SRF to the flame was studied, and the visual observations are described in this paper.

Figure 1. Camera inserted through side of kiln hood next to burner.

Results from Plant 1

Plant 1 has a production capacity of 3,500 ton clinker per day and has a thermal energy input in the kiln of 65 MW, of which up to 70 % comes from SRF. An example of the comparison between a petcoke fired flame and a co-fired flame with petcoke and SRF is shown in Fig. 2. When the flame is fully fired with petcoke the ignition point is between 3 and 4 meters from the burner tip. With SRF added to the flame the ignition point is delayed to 5-6 meters from the burner tip. The petcoke flame plume also appears wider, since the petcoke is fed through an annular channel close to the edge of the burner, while the SRF is fed through a pipe at the center. This causes the petcoke to more readily expand.
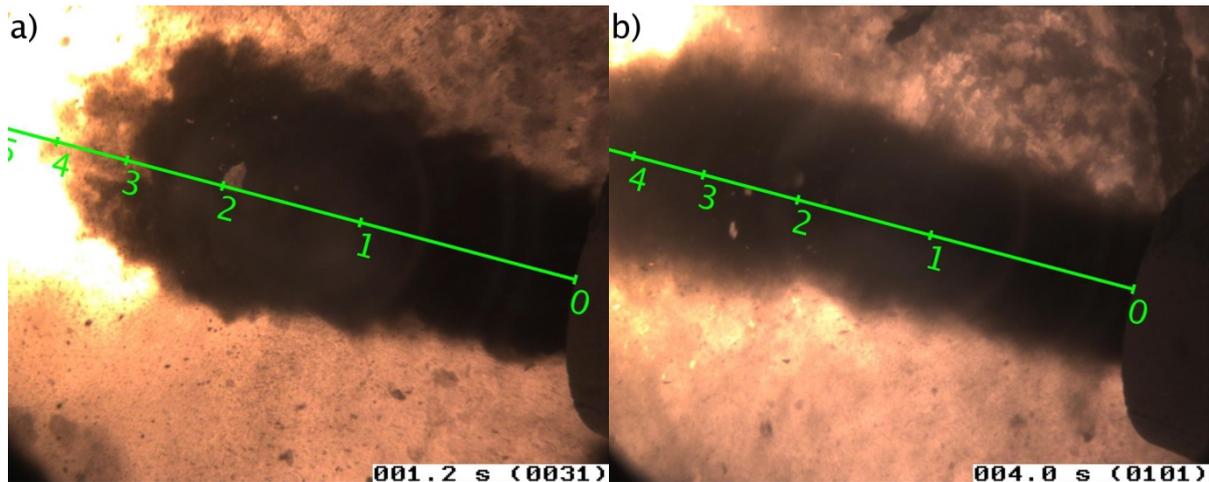

Figure 2. Flames from Plant 1. a) 7.5 t/h petcoke b) 8.5 t/h SRF and 2 t/h petcoke. The tip of the kiln burner is seen on the right.

At Plant 1 the kiln burner was recently changed. The most significant difference between the two burners is that the axial primary air channel was changed from an annular channel to 20 jets. In addition, a more powerful swirl air channel was added. Fig. 3 shows images of full SRF-firing from the old (Fig. 3a+b) and new burner (Fig. 3c) installed at Plant 1. It is noticed how difficult it is to ignite the SRF particles. As seen in Fig. 3b (view further down the kiln than Fig. 3a and c), the SRF travels far into the kiln before is starts burning. It can also be seen that it is difficult to disperse the large SRF particles, which tends to follow their initial injection trajectory. This allows the particles to travel in a highly concentrated fuel core, which is difficult to heat and ignite. The new burner (Fig. 3c) installed at the plant, is better at dispersing the SRF close to the burner. This will help in mixing the fuel with the hot secondary air (1000 °C), which leads to an earlier ignition.
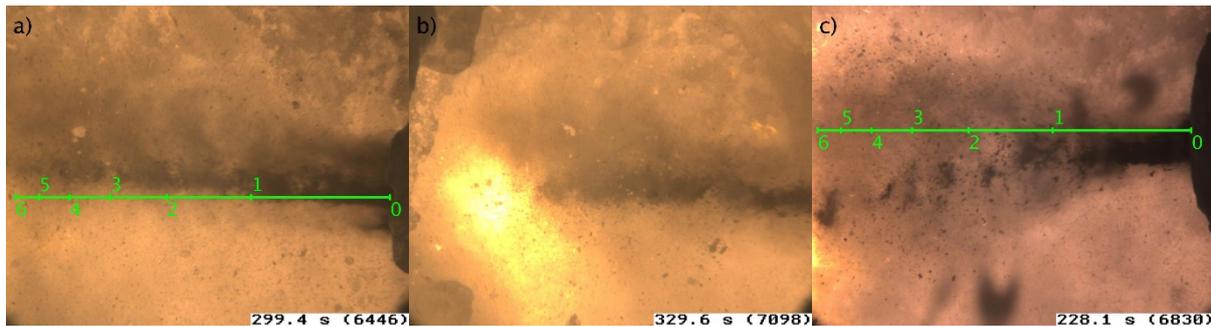
Figure 3. Full SRF-firing from old burner at Plant 1 (a+b) and new burner at Plant 1 (c). The view in image b is further downstream in the kiln.

Results from Plant 2

Plant 2 has a production capacity of 4,300 ton clinker per day. The thermal energy input in the kiln is 70 MW. The main fuel is a mix of coal and petcoke with up to 20 % of the energy coming from SRF. Fig. 4 illustrates the observations from Plant 2. Due to the higher volatile content of coal compared to petcoke, the flame is easier to ignite than the one at Plant 1 and 3, which fire only petcoke. As observed in Fig. 4a the flame starts to ignite within 1 meter. When SRF is added to the flame the ignition point is moved to around 4 meters from the burner. The image intensity is also lowered, indicating a decrease in flame temperature.
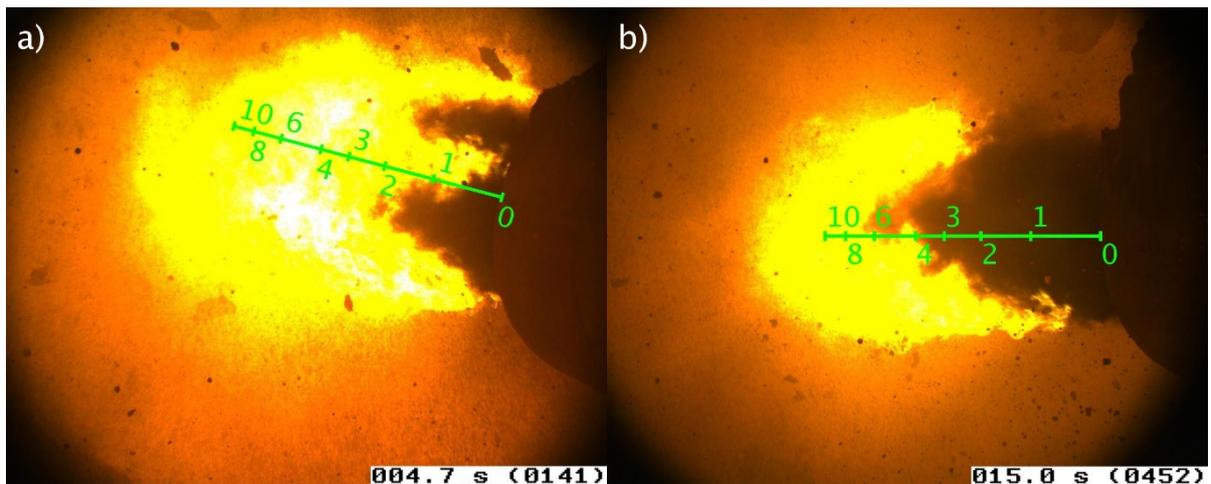

Figure 4. Flames from Plant 2. a) 10.5 t/h coal/petcoke. b) 5 t/h coal/petcoke is used with 4.5 t/h SRF (30 % SRF energy input)

Results from Plant 3

Plant 3 has a production capacity of 3,100 ton clinker per day. The energy input in the kiln is 65 MW and up to 50 % of the fuel is SRF and dried sewage sludge and the remainder petcoke. Some observations from Plant 3 are presented in Fig. 5, which shows two different co-firing scenarios. In Fig. 5a the fuel dosing is 3 t/h petcoke, 1.5 t/h sewage sludge and 6 t/h SRF. In Fig. 5b the dosing of petcoke has been increased to 4.3 t/h, while the dosing of SRF has been decreased to 5 t/h. This has a large impact on the flame intensity and thus the temperature in the clinker burning zone. It is important for the kiln operator to be aware of such changes when firing alternative fuels, where frequent flame adjustments might be required due to fluctuations in the SRF quality.
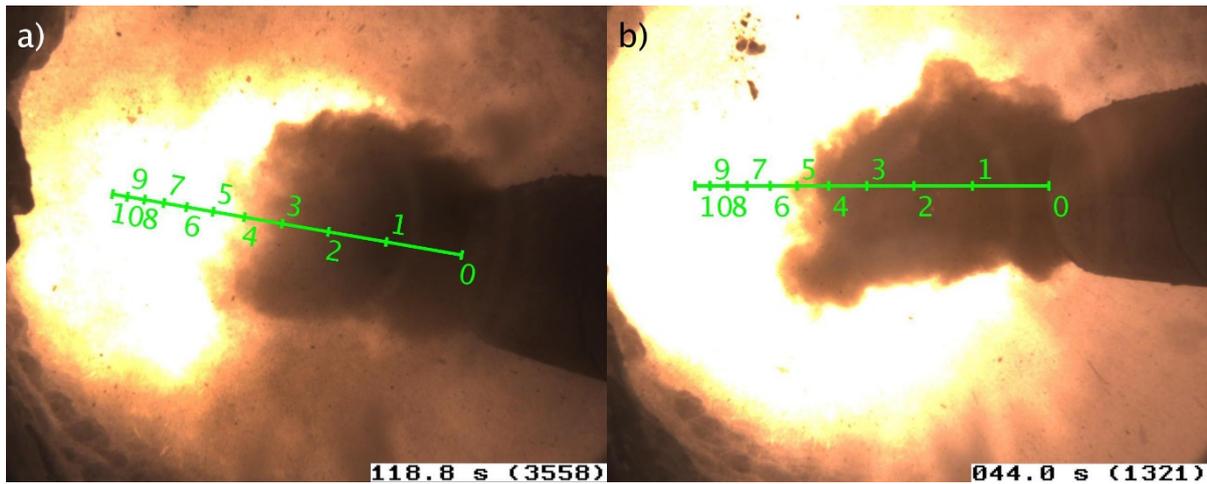
Figure 5. Flames from Plant 3. a) 3 t/h petcoke, 1.5 t/h sewage sludge, 6 t/h SRF (60 % AF energy input). b) 4.3 t/h petcoke, 1.5 t/h sewage sludge, 5 t/h SRF (45 % AF energy input).

Conclusions

A water-cooled camera probe that can be inserted into the cement kiln hood had been developed. It allows for detailed visual observations in the near burner region of the cement kiln of e.g. ignition point and fuel flow. The camera was used at three different cement plants to study the impact that alternative fuels (SRF) has on the flame. It was observed as a general trend of co-firing with SRF, that the ignition point of the flame is delayed by a few meters. The intensity of the flame zone is also lowered, indicating a lower temperature. This is caused by the larger particle size and higher moisture content of the SRF, which results in a longer heating and combustion time compared to fossil fuels. The lower combustion temperature may negatively affect the heat transfer in the cement kiln, lowering the cement quality.

At Plant 1 a comparison between two burners was made. It showed that the new burner at the site was better at dispersing the SRF. This will likely benefit the heating rate and ignition of the SRF, which results in an increased burnout with a positive impact on the cement quality.

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