INFACON 7, Trondheim, Norway, June 1995
Eds.: Tuset, Tveit and Page
Publishers: FFF, Trondheim, Norway

MEASUREMENTS OF BLOWS IN FESI FURNACES

E. B. Gudmundsson, I. Birnir and J. Hálfdanarson
Icelandic Alloys Ltd./Bresi Equipment Engineering
Grundartangi
301 Akranes
Iceland

ABSTRACT

At Icelandic Alloys Ltd. (IA), equipment and methods have been developed, to monitor continuously and instantaneously the efficiency of ferrosilicon and silicon metal furnaces. This is done by measuring on-line the silica dust concentration in stack gases by laser-based equipment. The equipment has become indispensable for the development and maintenance of improved stoking, charging of raw materials and other control procedures.

On the IA furnaces, the three individual smoke stacks coming from each furnace are joined to form one smoke duct over the roof of the furnace building. Originally the measuring equipment was installed on this common smoke duct. Further development of this measuring technique has led to measurements on each of the three stacks. The aim of these measurements is to monitor the local distribution of the dust production in the furnace and thus to indicate the location of concentrated blows.

By combining the dust concentration measurements with measurements of the temperature in the stacks it has furthermore been possible to study and reduce the fouling of the stacks.

Finally, the dust measuring equipment has also been developed for and installed at the filter house for clean gas monitoring. The purpose is to monitor the efficiency of baghouse filters regarding anti-pollution regulations to detect failures in baghouse filters.

1. COLFEM

The furnace efficiency tells us how much of the silicon of the raw materials comes out of the furnace as metal. The raw materials are either converted to metal or they end up in a smoke stack. Tapping and casting are batch processes, which means that data collected from that side, to calculate the furnace efficiency, will be historical when ready. Silica fume production is, however, continuous.

This has led to the development of indirect measurements of the furnace efficiency based on the monitoring of the dust production. The higher the dust production, the lower is the furnace efficiency.

A new system was developed at IA to measure optically the dust concentration in the smoke duct coming from the furnace [1]. The equipment features an electronically modulated laser source and digital signal processing in a built-in computer. This combination makes possible the large measuring range needed to measure through the whole smoke stack, which was not possible with other equipment using conventional light. The system was named COLFEM (the COntinuous Laser-based Furnace Efficiency Monitor) and is designed to withstand the hostile environment of ferroalloy plants. The optical filtering and electronic modulation also eliminate the influence of ambient light, mainly coming from sparks in the smoke.

Figure 1 shows a drawing of COLFEM installed on a smoke duct. Figure 2 shows the dust concentration as measured by COLFEM for a typical period from one of the furnaces at IA. The COLFEM signal is displayed along with a signal showing when the stoking car is in operation. The effect of stoking is quite clear. The operator gets an instant feed-back on how effective his stoking is.

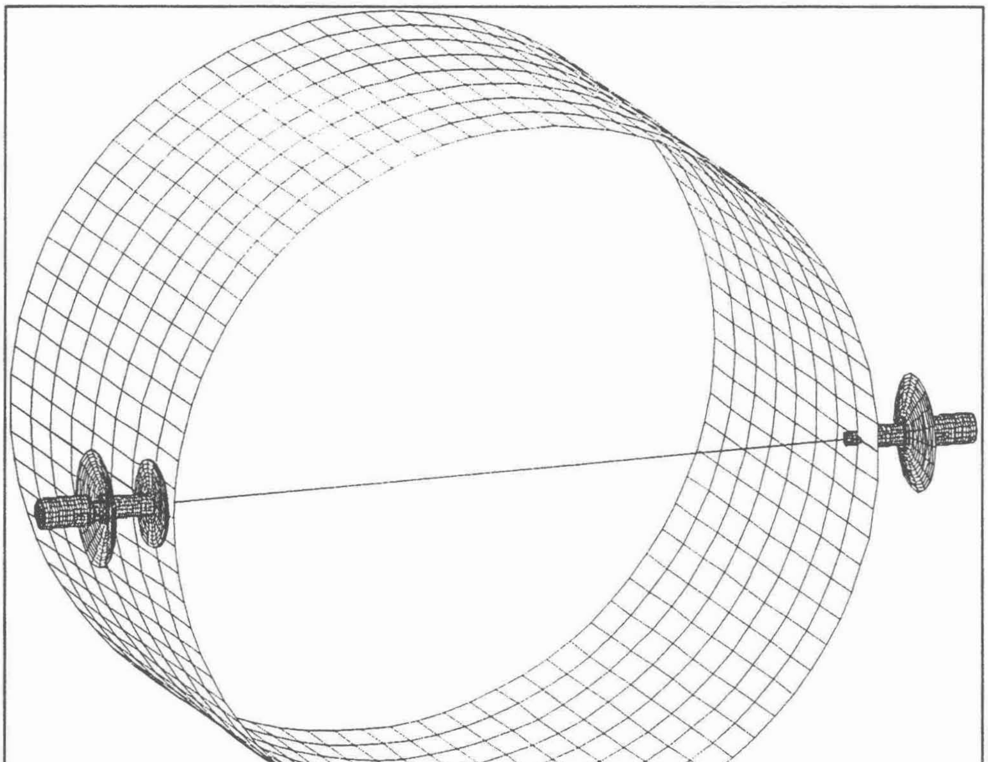


Figure 1: COLFEM installed on the smoke stack

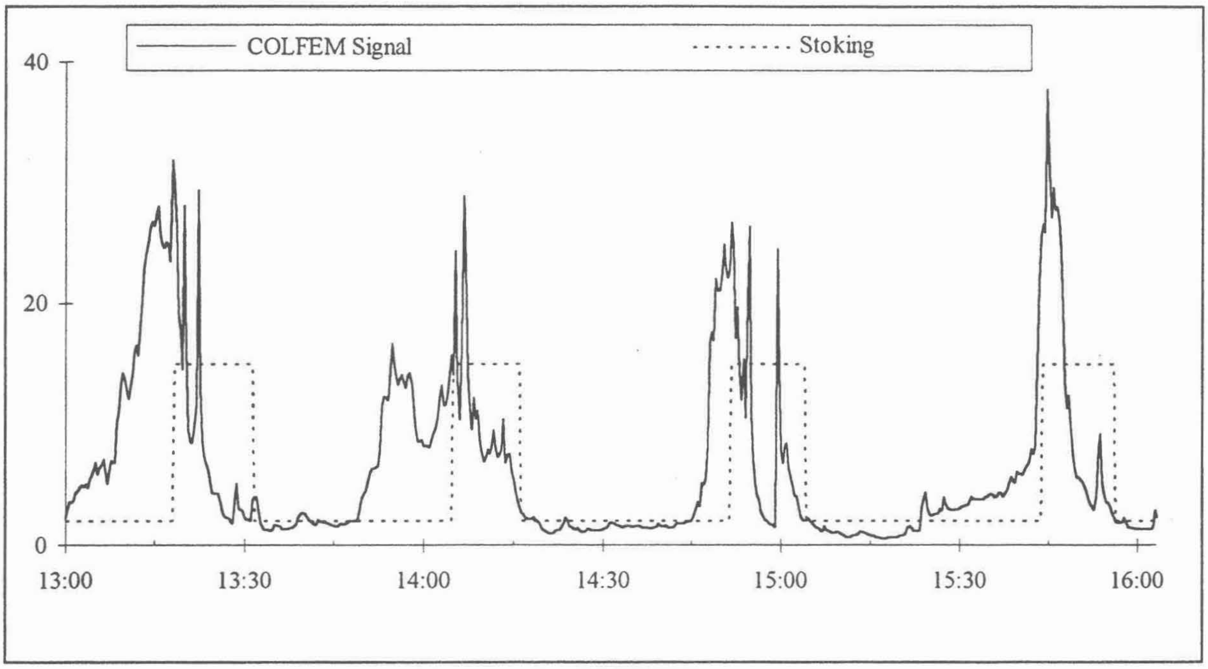


Figure 2: Dust concentration measurements in the smoke duct

To monitor the long time trend in the furnace efficiency, the COLFEM signal is also filtered with a time constant of 2 hours. Figure 3 shows the signals in a similar way as they are displayed on the control computer at IA. The variations in the efficiency over the 24 hours period can be clearly seen. This filtered signal can be used as an input for estimating the carbon control.

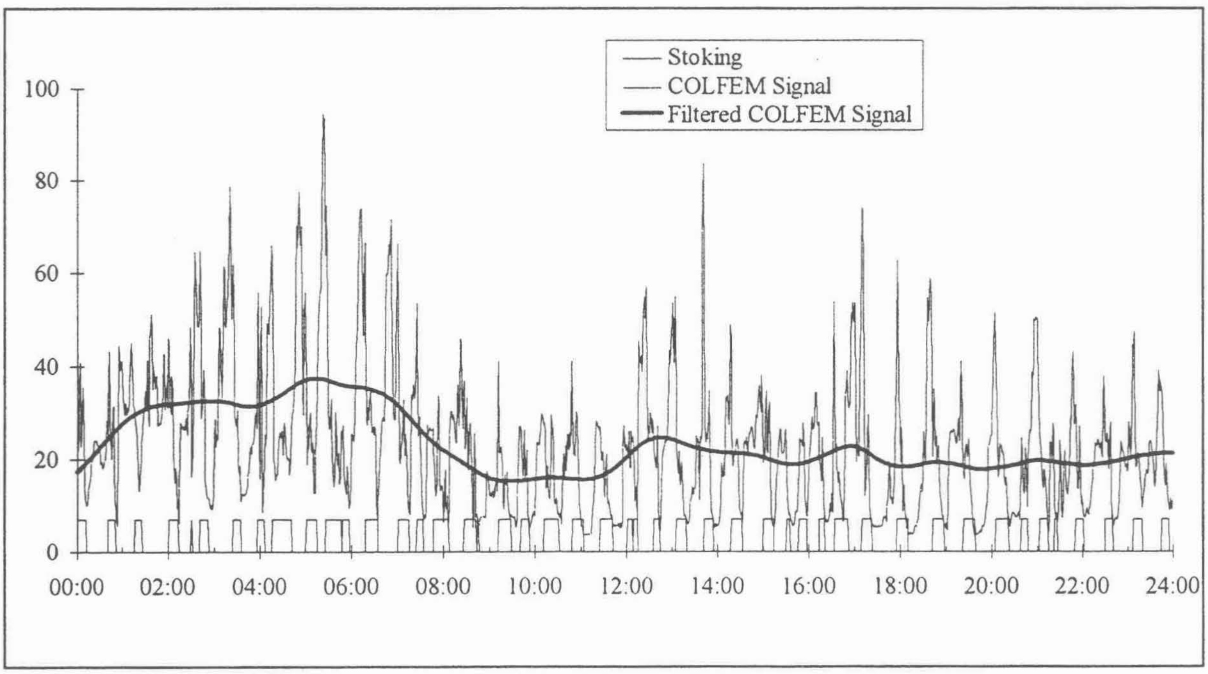


Figure 3: Filtered COLFEM signal from the smoke duct

COLFEM has now been in use at IA and several other plants for some years. The feed-back from COLFEM has been used to improve stoking and charging procedures. The results are very good and the furnace operators find the system indispensable for proper execution of these procedures and for a minute-to-minute information on the efficiency of the furnaces.

2. DETECTION OF LOCAL BLOWS

The knowledge of *when* blows occur in the furnace has proven to be of great importance, as described above. It was consequently considered that it might also be beneficial to monitor *where* in the furnace each blow occurred.

On the IA furnaces, the three individual smoke stacks coming from each furnace are joined to form one smoke duct over the roof of the furnace building. The first COLFEM was installed on this duct for measuring the mixture of dust from the three stacks. To monitor the local distribution of the dust production in the furnace and thus to indicate the location of concentrated blows, one COLFEM was installed on each of the three stacks.

The three electrodes are symmetrically located in the furnace. A smoke stack is at the periphery of the furnace behind each electrode (Figure 7). Whereas most of the blows occur close to the electrodes, a blow at one electrode should give a rise in the dust concentration in the corresponding smoke stack only.

Experiments confirm this assumption. Figures 4-6 show the signals from each of the stacks. During the measuring period, an observer on the stoking platform registered the real time and location of blows. His observations are marked on the graphs above the curves. The numbers to the right of the bars at the top of the graph correspond to the electrode numbers where the blows were observed. The blows near each of the electrodes can be "seen" in the corresponding COLFEM signal only.

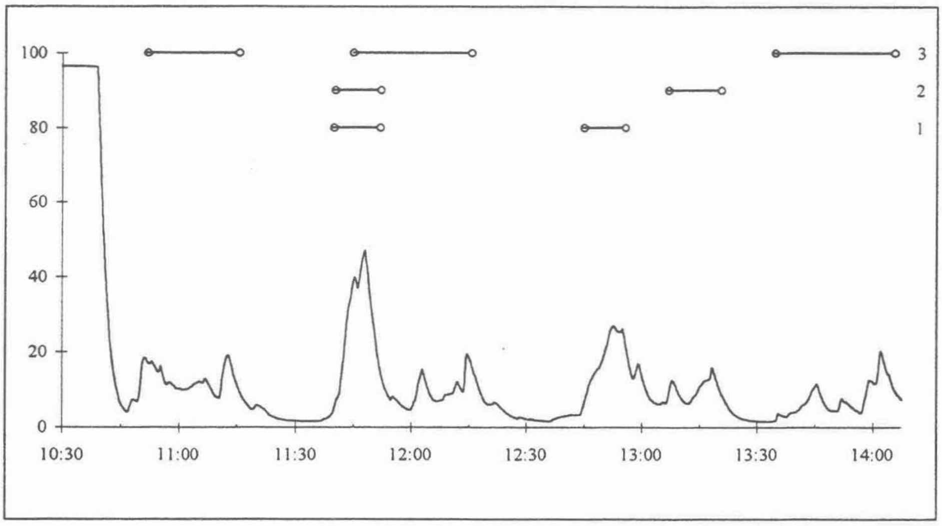


Figure 4: COLFEM signal from stack 1

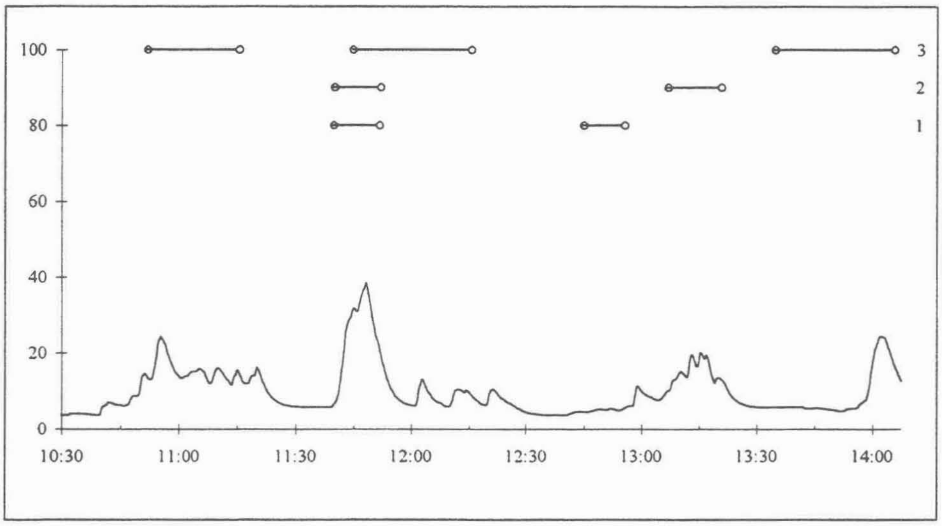


Figure 5: COLFEM signal from stack 2

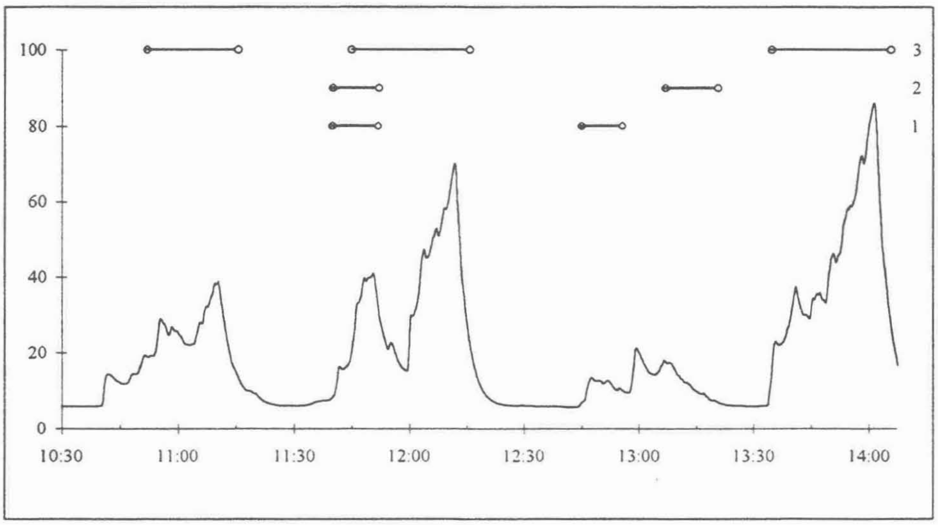
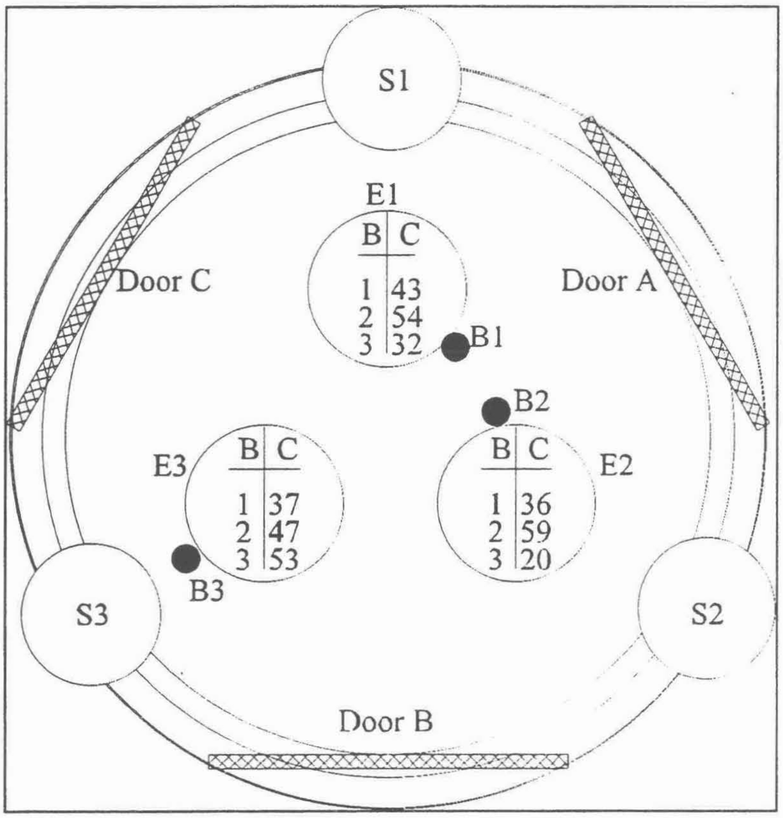


Figure 6: COLFEM signal from stack 3

In another measuring period the observer tried to estimate the "size" of the blows quantitatively. The correlation between the three "size of blow" signals and the three COLFEM signals was calculated. Figure 7 is a schematic drawing of the furnace. The correlation coefficients are listed inside each electrode. The first number is the correlation between this stack's COLFEM signal and the blows near the first electrode, and so on. Also shown in the figure are the dominant positions of each blow during the period.



E: Electrode number
B: Blow number
C: Correlation coefficient
S: Stack number

Figure 7: Correlation between blows and COLFEM signals on stacks

It is clear how the correlation coefficient is biggest between each electrode's "size of blow" and the COLFEM signal of the nearest stack. This is the more obvious, the farther away from the other electrodes the blows are. The blow near electrode 3 is e.g. located near the furnace edge, away from electrodes 1 and 2. The correlation coefficients reflect this situation clearly.

The correlation coefficients are displayed on the figure multiplied by 100 and can therefore be interpreted as percentages. The "size of blow" signal, as estimated by the observer, is, however, an approximation. More attention should therefore be given to the relative comparison of the coefficients than to the absolute values of the coefficients themselves

From the four signals, from the three stacks and the duct, it is relatively easy to see instantaneously where the furnace is blowing. The operators can then take the necessary measures regarding stoking and charging.

3. FOULING OF SMOKE STACKS

Fouling of smoke canals due to sintering effects in the deposited dust layers is a problem in systems with high and varying gas temperature, like FeSi producing furnaces. Physical cleaning of smoke ducts must be done at regular time intervals. During the cleaning period the load must be taken of the furnace resulting in shorter operating time.

As the waste gas temperature increases, the sintering of the dust in the smoke ducts is accelerated. Even at temperatures which are approximately 50 % lower (on the Celsius scale) than the melting temperature some sintering effects can be recognised [2]. When the temperature in the smoke duct reaches 1000°C sintering becomes a serious problem [3].

The temperature of the waste gas is a function of the amount of SiO and CO gases released from the charge, heat from burning of volatile matter released from coal and coke and how much air is drawn into the furnace. The temperature variations are large due to stoking, charge collapses, local gas blows, etc.

At IA lack of symmetry in the waste gas flow from the furnace causes uneven heat distribution between the three smoke stacks. To map this difference a fast responding thermometer was installed on each of the three stacks one meter below the already installed COLFEM unit. Figure 8 shows the variations in silica fume concentration and temperature during a stoking period.

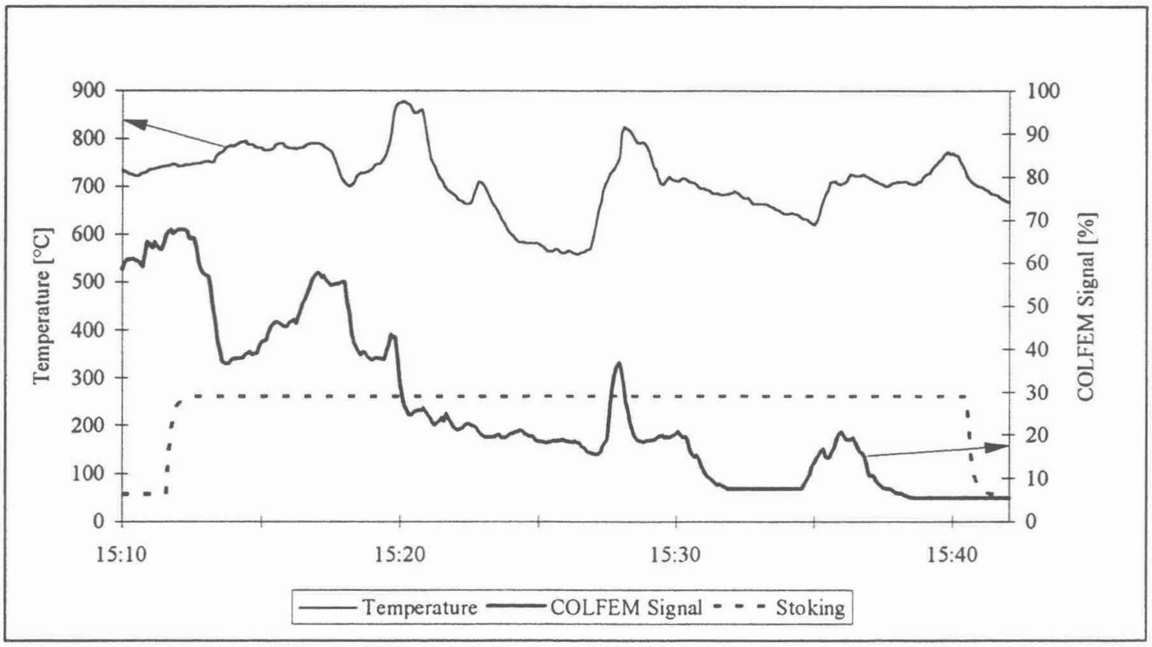


Figure 8: Variations in silica fume concentration and temperature during a stoking period

Normally the highest temperature was reached during stoking when fines and volatile matter from new carbon material were burning. Peaks in excess of 1000°C were observed.

The SiO gas that escapes from the furnace charge reacts with oxygen at the furnace top to form silica fumes. It is the amount of these fumes that COLFEM measures. By combining the on-line measurements of the dust concentration and the temperature it was thus possible to determine if the temperature changes were due to local changes in the SiO concentration or the changes in the flow patterns of the waste gas through the furnace.

The furnaces at IA are semiclosed with three doors that are closed between stoking periods, see figure 7. Figure 9 shows the changes in temperature of the waste gas in the smoke stack behind electrode 1 due to opening and closing of different doors of the furnace.

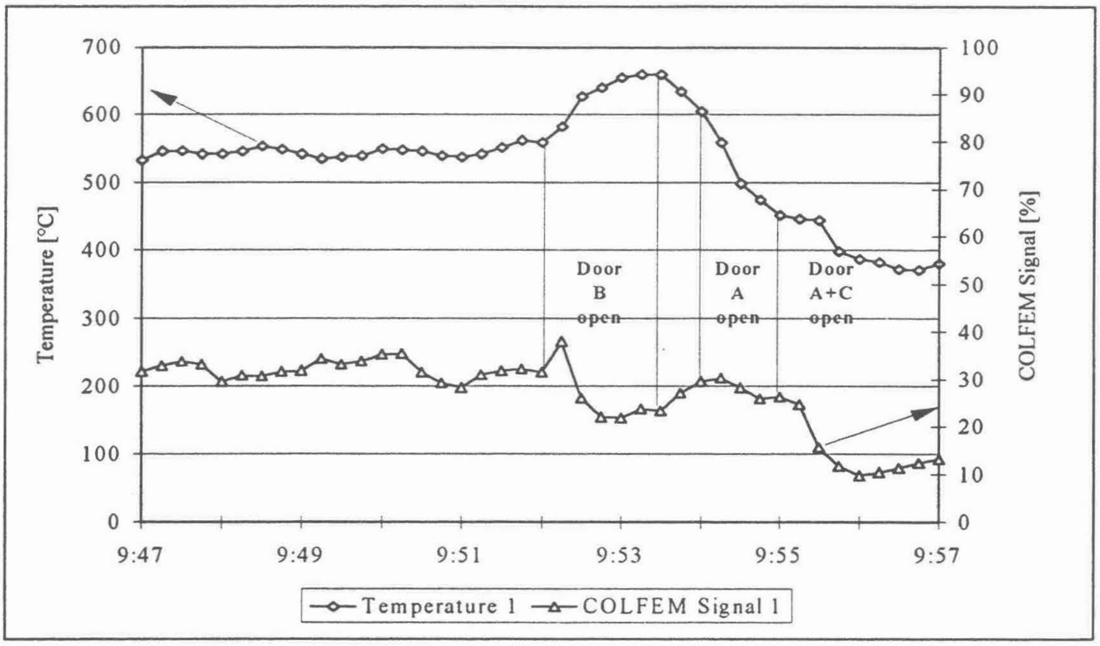


Figure 9: Temperature changes due to opening and closing of furnace doors

Since the COLFEM signal is not rising with the temperature, the increase in temperature can not be due to higher SiO concentration in the waste gas. It must therefore be a result of the changes in the flow patterns of the waste gas caused by opening door B of the furnace.

The combined on-line dust concentration and temperature measurements have led to changes in the working routines during the stoking period. The main difference is that now two doors are kept open when stoking. Figure 10 shows a comparison of the temperature distributions for the two procedures.

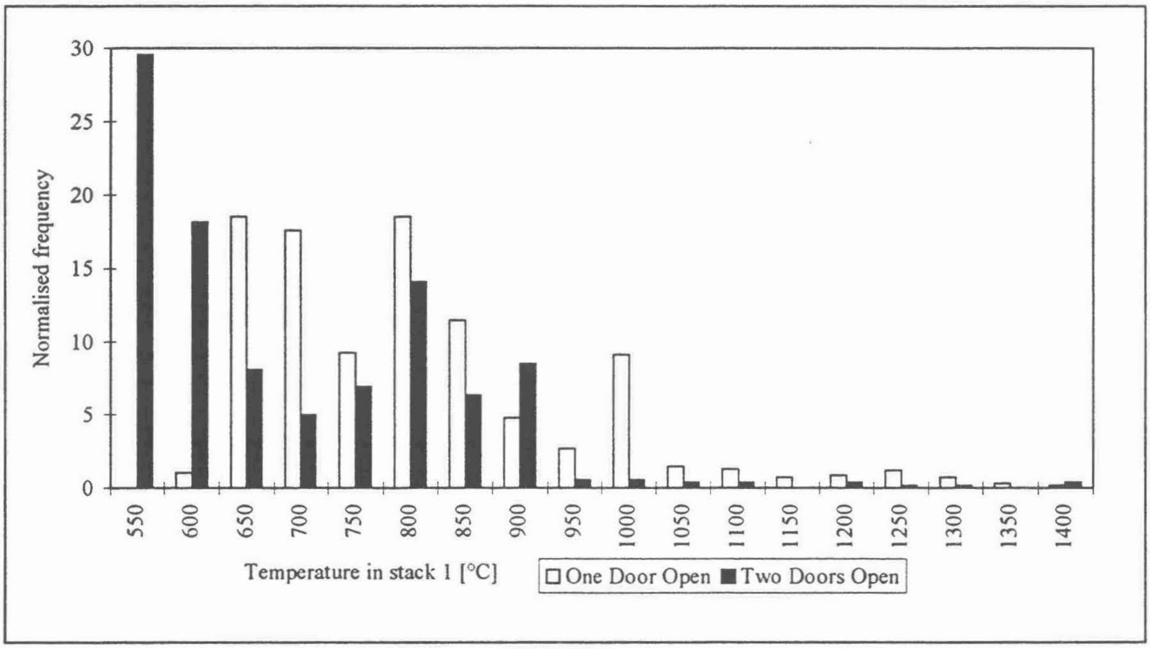


Figure 10: Normalised temperature distribution for smoke duct one during stoking, with one or two doors open

By changing the routine for opening doors while stoking, it was possible to almost eliminate temperature "peaks" around 1000°C and lower the average temperature during stoking by 130°C. The result is longer operation time and less wear of the furnace.

4. POLLUTION MEASUREMENTS

Having developed COLFEM for dust concentration measurements in the stack, it was decided to develop it further for other applications. The first obvious application was to measure the dust pollution in the exhaust gases from the baghouse filter. This has two main purposes.

The first one is to monitor the efficiency of baghouse filters regarding anti-pollution regulations. Such regulations will be even stricter in the near future. This means that equipment, developed for the hostile environment in such plants, will be needed to verify the adherence to regulations, on-line as well as historically with the suitable data accumulation.

The other purpose is to detect and report failures in baghouse filters, such as torn filter bags. This is very important, since torn filter bags tend to flap and damage adjacent bags. The need for an immediate detection is therefore obvious.

A new version of COLFEM, capable of measuring the low dust concentrations in baghouse filters as well as the high concentrations in stacks, was developed. To test COLFEM for this new application, it was installed earlier this year in one of the baghouses at IA. Figure 11 shows the COLFEM signal from the baghouse filter. The cleaning cycle of the filter takes 17 minutes. This cycle is clearly reflected in the periodical pattern of the signal.

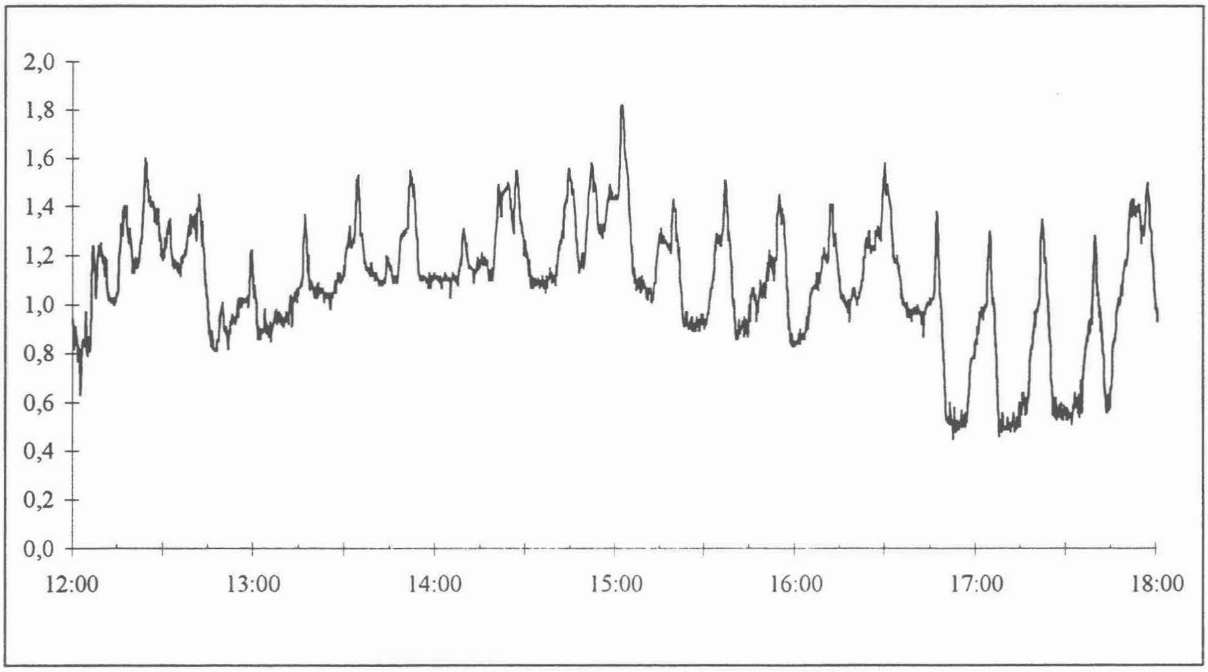


Figure 11: COLFEM signal from baghouse filter

Further applications will include monitoring the quality of the working environment in the furnace house and at other places where people are working.

5. SUMMARY

The main findings of this paper can be summarised as follows:

1. Furnace efficiency measurements by COLFEM have become an indispensable tool to improve and maintain control procedures such as stoking and charging.

2. Monitoring of the location of blows, by installing one COLFEM on each smoke stack, gives a more detailed information, which is helpful in controlling stoking and charging.

3. The combined measurements of dust concentration and temperature have made it possible to study and reduce the fouling of the stacks.

4. Measurements of dust pollution in exhaust gases will be necessary to fulfil anti-pollution regulations and are useful for reducing the number of damaged filter bags.

ACKNOWLEDGEMENT

We would like to express our thanks to the staff at IA for their co-operation and support during the development of COLFEM and the relevant experiments.

REFERENCES

1. Gudmundsson, E.B. and Hannesson, T. On-line laser measurements of silica dust. *INFACON 6. Proceedings of the 6th International Ferroalloys Congress, Cape Town.* Volume 1. Johannesburg, SAIMM, 1992. pp 201-204.
2. Johansen, S.T.. Fouling of walls in systems where hot, dusty gases are transported. SINTEF-report, STF34 A88012, 1988.
3. Johansen, S.T. Grådahl, S. Raaness, M.. Groing av gassløp over FeSi-omnar. SINTEF-rapport, STF34 F90070, 1990.