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

ELECTRODE LENGTH MEASUREMENTS WITH ELMO

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

Abstract

The paper describes a method developed at Icelandic Alloys Ltd. for determining the length of the electrodes in a submerged electric arc furnace. The system is in use on two 36 MW furnaces that produce 75% FeSi. Weighing cells are installed under the hydraulic cylinders suspending the electrode. The signals from the cells are treated in a computer program to reduce their noise level and the electrode lengths are calculated from the weight. All results are presented in clear graphics on the computer screen.

Introduction

Furnace operators dwell every day on the questions: How long is the electrode? How deep is the tip position? These are actually two aspects of the same statement as the tip position is a direct function of the electrode length and the holder position.

The first question concerns the electrode itself and the accurate answer allows an optimal operation of the Söderberg electrode with the correct slipping rate adjusted in accordance with the measured consumption.

The second question is related to the electrical and metallurgical conditions in the furnace. The knowledge of the current tip position gives the operator a better tool to optimise the carbon balance of the furnace and the electrical set point.

The traditional method for sounding the electrode has been to melt down the charge, shut down the current, raise the electrode and locate the tip by pressing iron bars below it. This reduces the operating time and interferes with normal furnace operation. Therefore frequent use is not advisable.

The weighing of the electrode is a straightforward way to determine the length. With Söderberg electrodes accurate accounts must be kept of new casings added and the amount of paste charged. The furnace charge causes however buoyancy and friction effects which can easily introduce errors in the weight determination. With modern computer technology these obstacles can be overcome as will be described in the next chapter.

ELMO

The Electrode Length Monitor (ELMO) is a electrode weighing system that has been developed at Icelandic Alloys for measuring the length of the electrodes. Figure 1 shows a schematic drawing of the system.

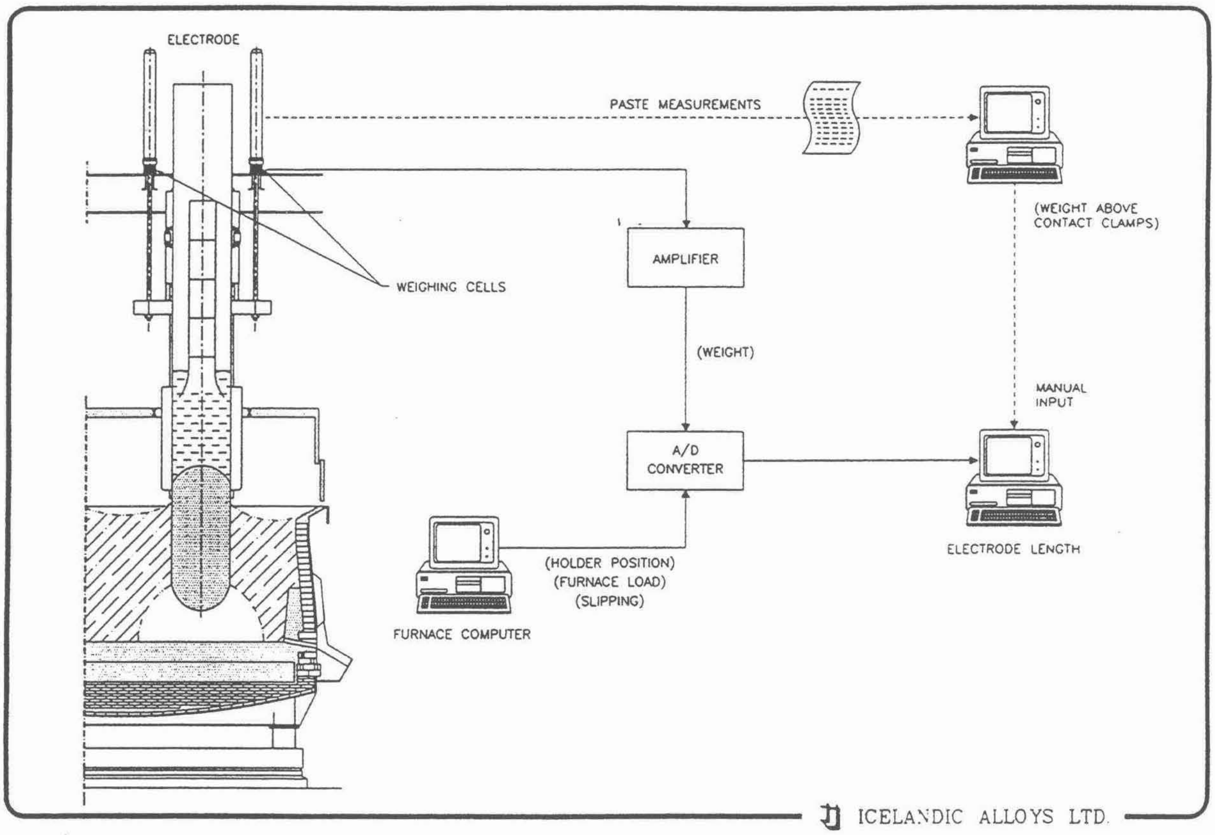

FIG. 1. ELMO, schematic drawing of the system

The two furnaces are run on 36 MW each and have Söderberg electrodes with a diameter of 155 cm. For the weighing, load cells are placed under the two hydraulic cylinders that suspend the electrode and move it up and down. The weighing cells are specially constructed to fit under the cylinders, around the piston rods.

The signals from the weighing cells are amplified in an amplifier and forwarded to an analog/digital converter that is connected to an industrial computer. The computer is also connected to the furnace control computer and gets from there continuos registration of the holder position of the electrodes, the slipping and the furnace load.

The weight values are filtered and evaluated in a specially developed computer program. From the total weight of the electrode the variable weight of the electrode above the contact clamp has to be subtracted. For this purpose the time of paste addition, amount of paste and time of addition of new casing has to be entered into the computer.

From the inputs the computer calculates the electrode length and displays it among with other relevant information. The program runs under Microsoft Windows and is illustrative and user friendly.

Figure 2 shows a picture of the electrodes as they are displayed on the computer screen. The picture is updated every minute. To the right in the picture the furnace load is shown as a column, the man with the butterfly starts to smile when the load passes 35.0 MW. The electrodes are shown as cylindrical with a flat end. The method determines the average length of the electrodes and cannot detect how far they are "pencilled" or in other way deviating from an ideal cylindrical shape.

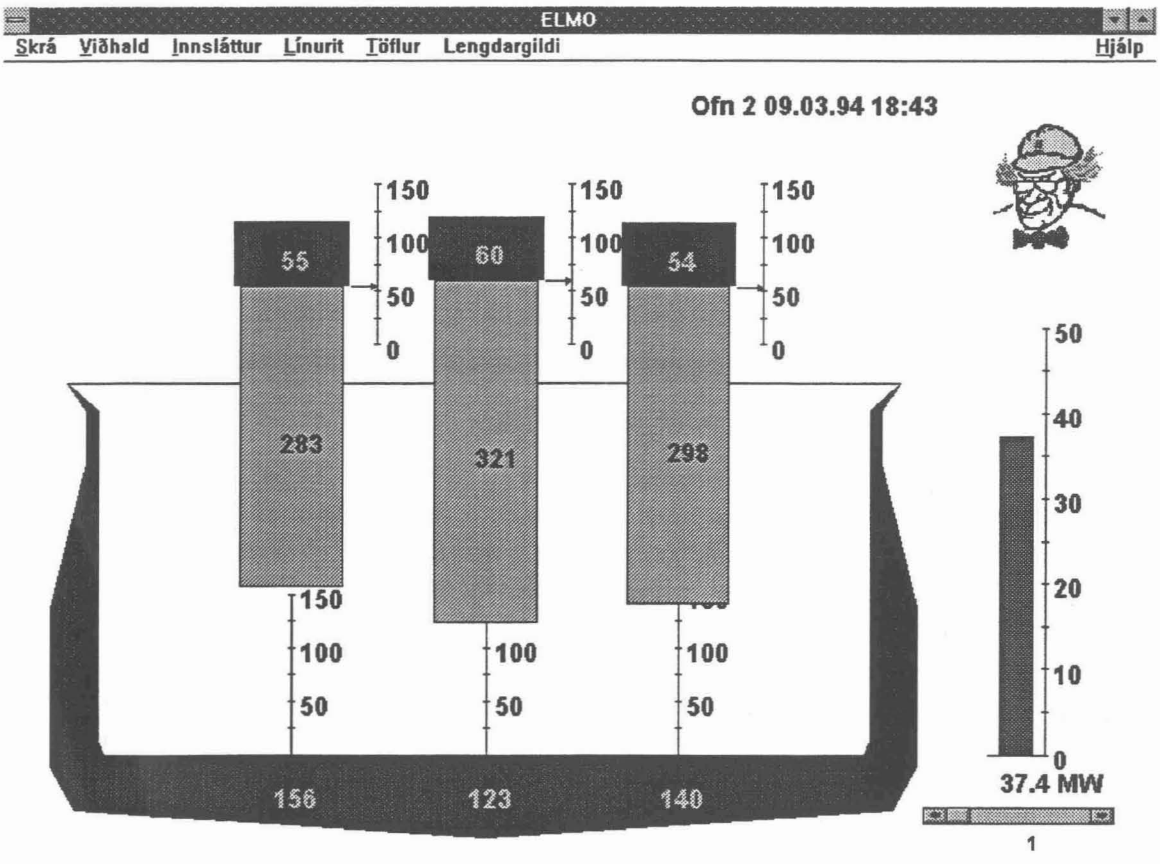

FIG. 2. ELMO, computer display of the electrodes

Figure 3 shows another display of the computer. The picture is here in black and white but in colour on the screen. The weight of the electrode (presented in the unit cm of electrode length) is shown as a function of time (over 26 hours). Furthermore the holder position of that electrode and the furnace load is drawn.

The scattered points show the minute by minute values of the electrode weight. Clearly these give little information without statistical evaluation. Three curves are drawn through the points, two show the weight values filtered with different time constants and the third is the best line between time of addition of paste, calculated by linear regression.

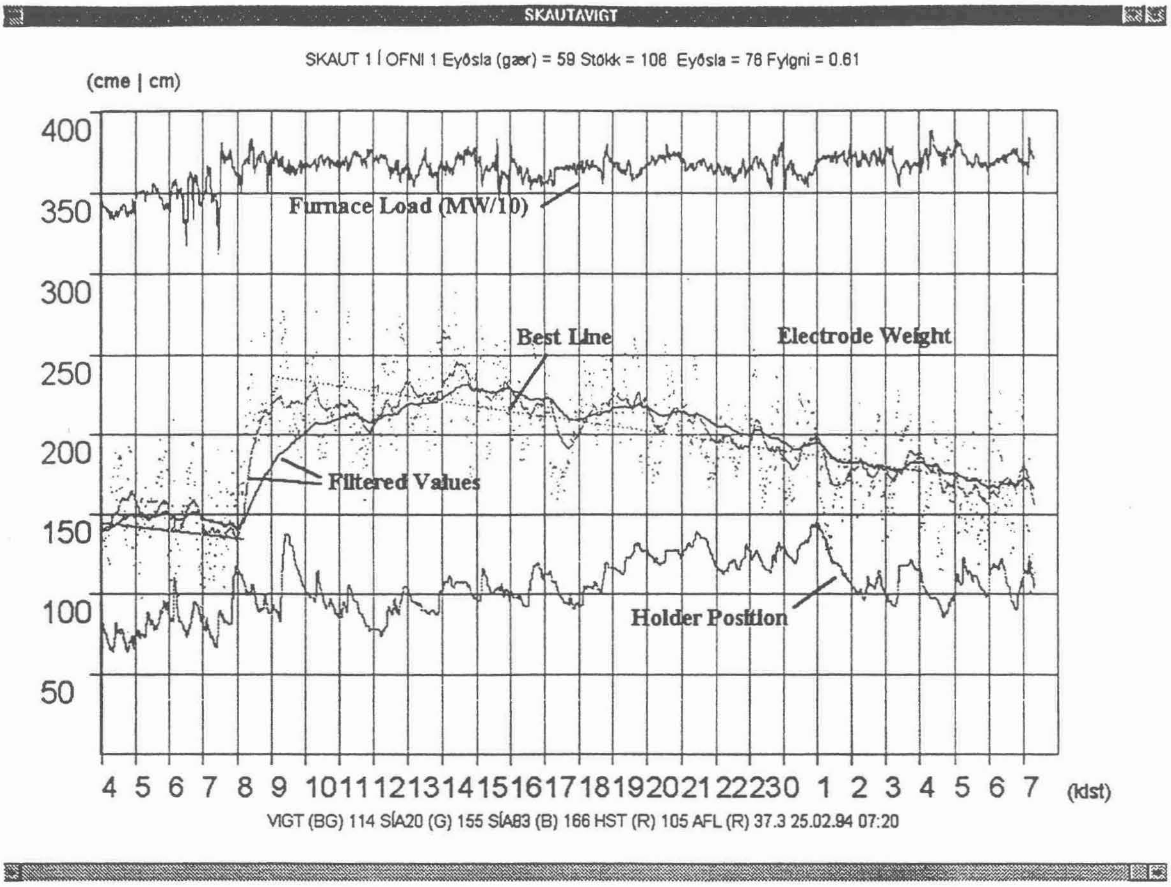

FIG 3. ELMO, display of the weight of the electrode

The figure shows how the weight decreases as the electrode is consumed during the day. At the beginning of the day shift (8:00 hour) new paste is added to the electrode casing causing a step increase in the weight. Then the curves fall slowly according to the consumption until new paste is added the next day.

The filtered weight values are corrected for the movement of the electrodes as a downward movement makes the electrode slightly lighter and an upward movement heavier. Therefore a small correction factor is added if the electrode is on the way down and subtracted if the electrode moves up.

The computer registers the weight at intervals of 10 seconds. It excludes values out of limit and takes the average over one minute of the remaining values. The screen pictures are updated with that frequency.

Figure 4 shows the current electrode length of the three electrodes as evaluated by the computer. In the lower part of the picture the cumulative slipping lengths of the electrodes are shown. The values are put to zero at seven o'clock each morning.

To calculate the current electrode length the computer uses the filtered weight values. To the filtered value the slipping length is continuously added. Furthermore the effect of the paste and casing addition is taken into account. That information is put in manually but if no new data is entered the computer uses the values it calculates from the steps it detects in the weight curves when new paste is added.

The picture of the current electrode length is important for the furnace operators and very illustrating. One look at the picture tells if the electrodes are becoming shorter or longer during the day. The electrode consumption is a reflection of the carbon balance of the furnace as is the tip position. Furthermore an irregularity such as breakage is detected.

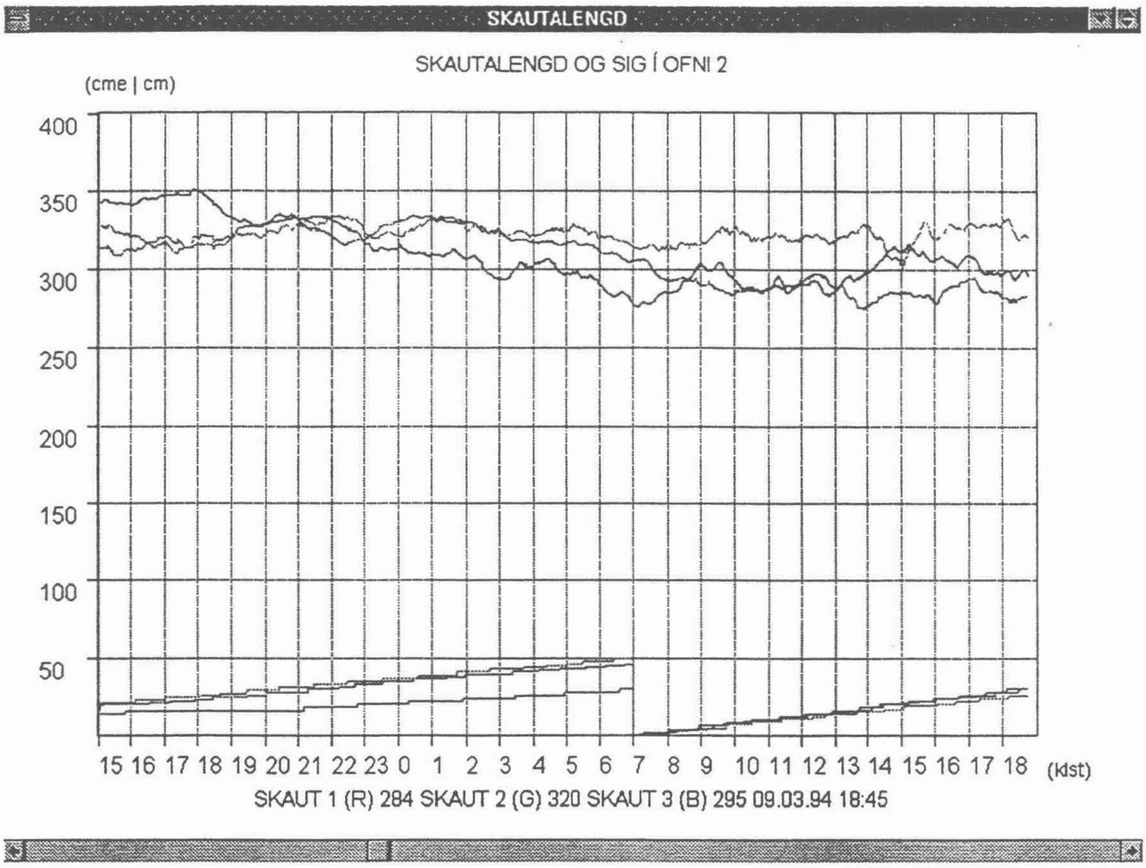

FIG. 4. ELMO, current length of the electrodes

Figure 5 shows a breakage of electrode 1, 120 cm falls off the electrode. Figure 6 shows the weight values for that occurrence. The breakage was not clearly seen in the behaviour of the furnace or any other parameters measured. But action as increasing the slipping rate could be taken immediately to prevent further consequences.

Soft electrode breakage

In the period when the electrode weight system was developed a soft breakage occurred on one of the electrode of the furnace. Molten electrode paste poured into the furnace. Simultaneously a huge explosion shook the furnace building, ripping off a part of the roof together with some of the wall panels. It was quite clear that the explosion occurred inside the electrode column. People were however uncertain as to the correct sequence of events or cause and effect, that is which came first, the breakage or the explosion.

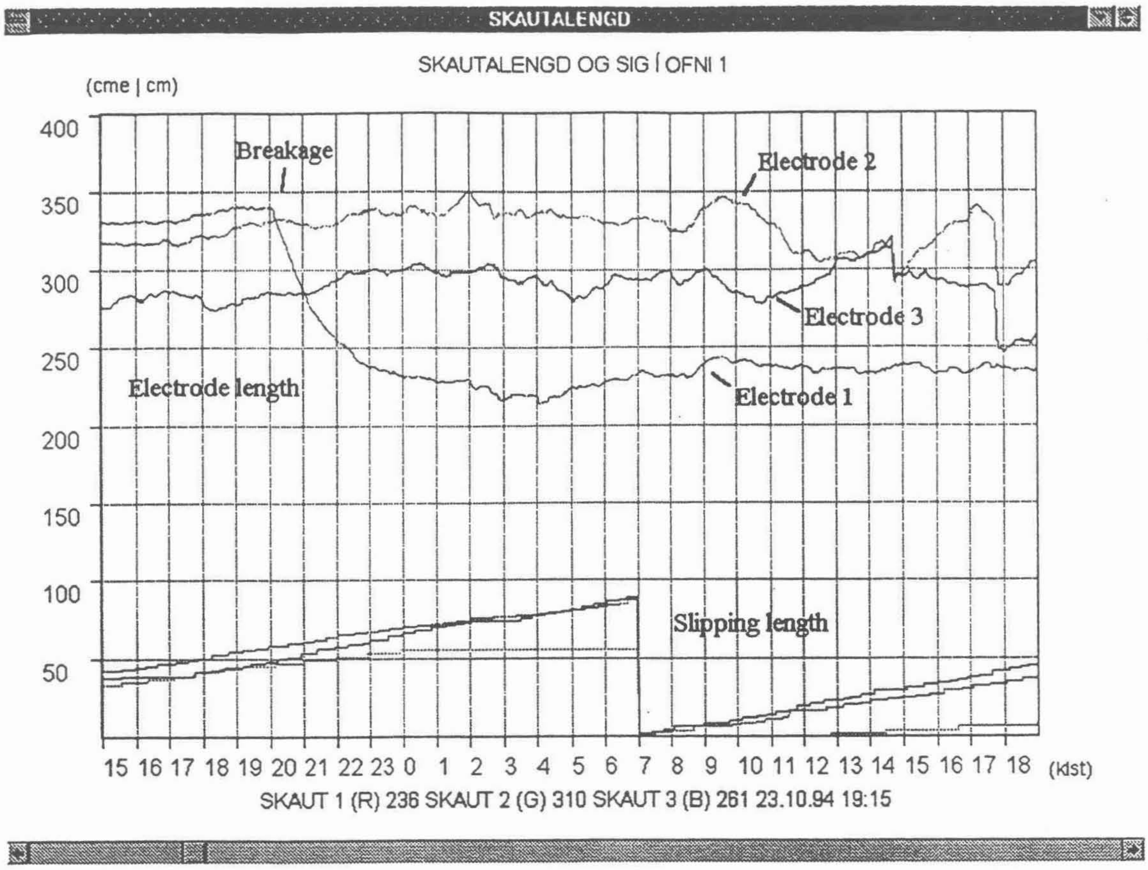

FIG. 5. Electrode breakage, length of the three electrodes

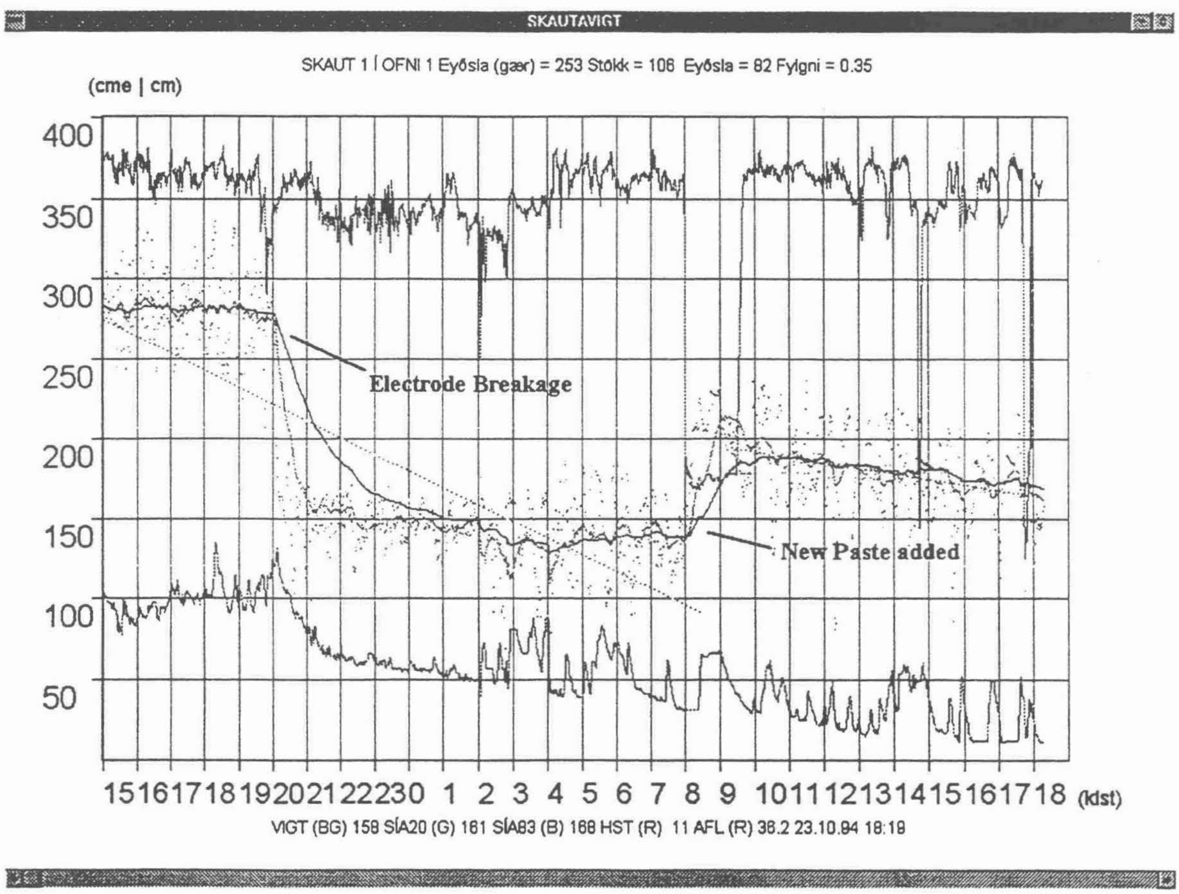

FIG. 6. Electrode breakage, weight of the broken electrode

The data from the electrode length measurements revealed the course of events. The electrode length computer recorded the minute values for the furnace load, the holder position and the weight of the electrode. Therefore it was possible to go back and print out the sequence as shown in the attached Figure 7. As can be seen from the figure, most of the molten paste poured into the furnace in less than one minute. Then the flow slowed down during the following six minutes. At that time a hole must have opened up through the remaining paste, allowing gases (volatile matter from the paste) to rise up into the electrode column that acted like a chimney. There the gases exploded with a devastating effect and the explosion pressed out some of the remaining molten paste. Two minutes after the explosion the furnace was switched off.

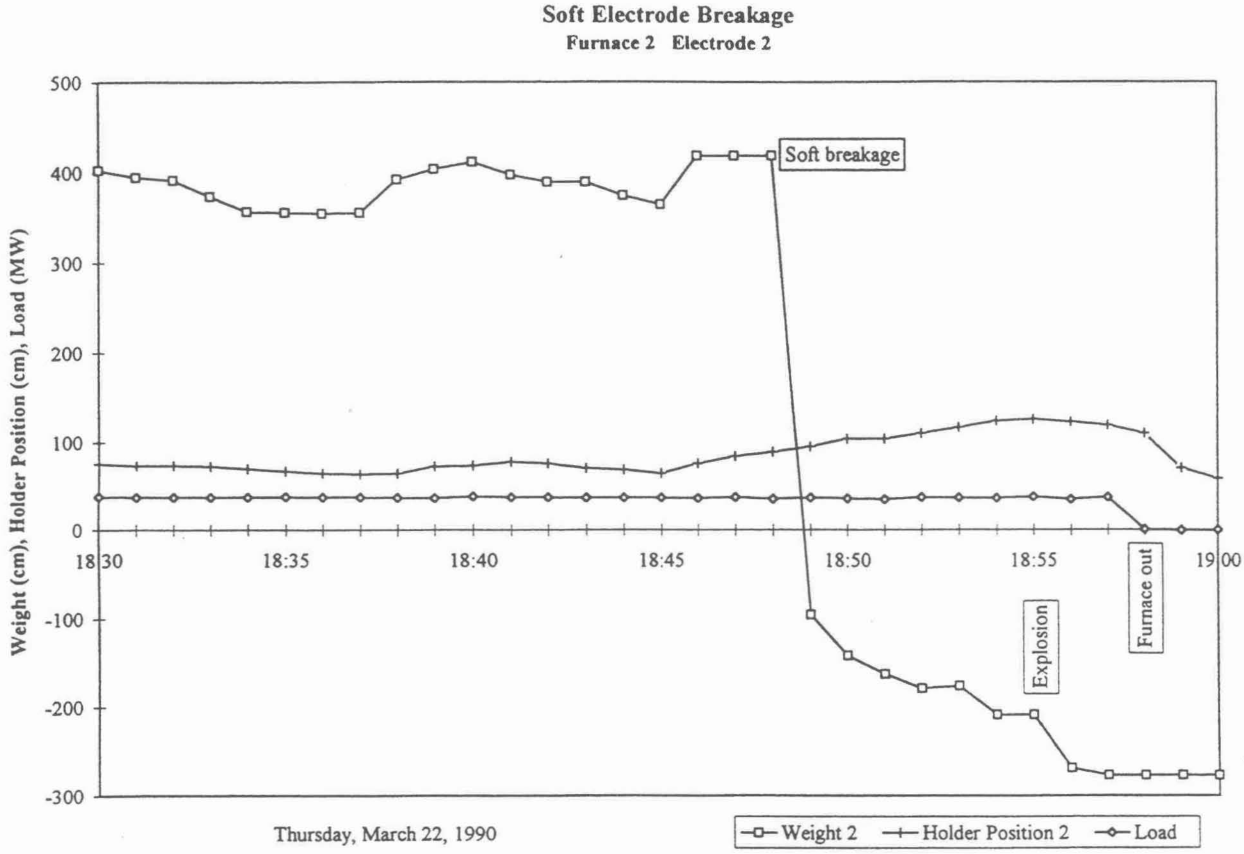

FIG. 7. Soft electrode breakage

As described seven minutes passed from the breakage until the explosion. This is a fairly long time. The operator was operating the stoking car and stoking the furnace at the furnace door opposite the electrode that broke. The break was not detected until the explosion.

ELMO now gives a warning signal when it detects a sudden weight change of the electrode. This reduces the risk of an explosion following a soft electrode breakage as the furnace operator will have time to shut down the furnace and press down the electrode. In the event described this would have prevented the main damage. As to the electrode breakage that occurred during a fully normal furnace operation, no explanation was found to its cause.

Summary

ELMO, an electrode weighing system for monitoring the electrode length has been in use for several years at Icelandic Alloys. It has been constantly improved. The current version of the program runs under Microsoft Windows. It is user friendly and displays the information in different graphics and trend curves. It gives inputs for controlling the carbon balance and the electrode operation. It reduces the risk of explosion in a connection with a soft electrode breakage.