Subscriber Soodakattilayhdistys 17.9.2010

FURNACE TUBE TEST PROBE

The aim of this test was to expose selected materials to recovery boiler furnace conditions for 1000 hours so that the average material temperature (on furnace side surface) is 440°C ± 10°C. Materials tested in this test were 3R12 (304L), San 38, Super 625 and HR11N.

The test was started by installing the test probe in place on 16th of July 2010 at 9:00 am. Set value for the system pressure was set at 7,8 bar(a). The test began when pressure exceeded 7,0 bar(a) on 16th of July at 1:00 pm. The saturation temperature of heat transfer oil exceeded then 370°C (about 20°C more than water saturation temperature at 170 bar pressure).

The test was completed on 6th of September 2010 at 2:36 pm when the probe had been exposed to boiler furnace conditions for 1250 hours. The duration of the test was extended from 1000 to 1250 hours in order to achieve roughly the same operating time at the minimum of 7,0 bar(a) as in the previous test. Now the probe operated at this pressure range for 750 hours, while in the previous test the corresponding time was 830 hours.

The installation and initial settings of the probe

The test probe was equipped with two thermocouples, which were installed vertically and horizontally in the middle of the top and the bottom test pieces. The set value for system pressure was selected on the basis of the thermocouple readings and the data from previous tests. The pressure was adjusted with a cooling fan regulated by PI controller. When the pressure was set at 7,8 bar(a) the upper thermocouple gave readings around 400 °C and the lower one temperatures around 406 °C. The pressure target value was decreased down to 7,3 bar(a) on 27th of July 2010 at 10:45 am in order to keep the test piece temperatures at allowable level according to thermocouple readings. On 3rd of August at 2:40 pm the pressure target value was increased to 8,5 bar(a) when it was discovered that the thermocouples hadn’t been working properly at the time the pressure was decided to decrease.

The probe was also equipped with electric heating elements to make sure that the system pressure would not drop too low when the probe is covered by black liquor (the probe was installed in an empty liquor gun opening, i.e.

close to operating liquor guns). The electric heating elements were automatically turned on/off when temperature of the test device dropped below/increased above a set point. The set point was selected so that the system pressure would remain above 4 bars (with saturation temperature more than 330°C) at all times.

The results

Although the intention was to use only the black liquor sprays which in the past had been shown to yield relatively stable load on the test probe, the instructions to the operators were misinterpreted and, as a result, black liquor sprayed on the probe nearly constantly during the first 230 hours (between 16th and 26th of July). As a result, probe pressure remained low most of the time. During this period it was also discovered that heating elements were not working properly. Consequently, probe pressure fluctuated more than in the previous tests. However, the pressure fluctuations during the first week were tolerated without any test material temperature surges above 450°C, see Figure 1. The graph shows the thermocouple temperatures, calculated cooling oil saturation temperature and probe pressure between 16th and 27th of July.

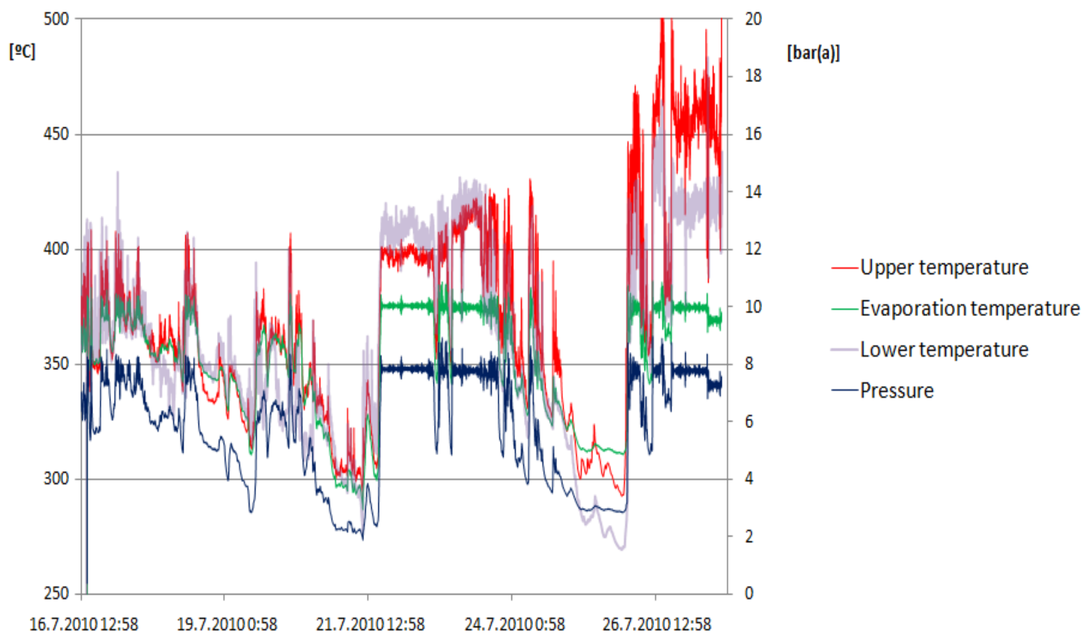


Figure 1. Thermocouple temperatures, system pressure and cooling oil saturation temperature 16. - 27.7.2010.

Both of the thermocouples broke down on 26th of July and the temperature readings started to climb and fluctuate. That can be seen in figure 1. The reason for the failure was probably inadequate casing of thermocouple.

The locations of operating black liquor guns were corrected on 26th of July, and, as a result, probe pressure fluctuations were scaled down considerably, see figures 1 and 2.

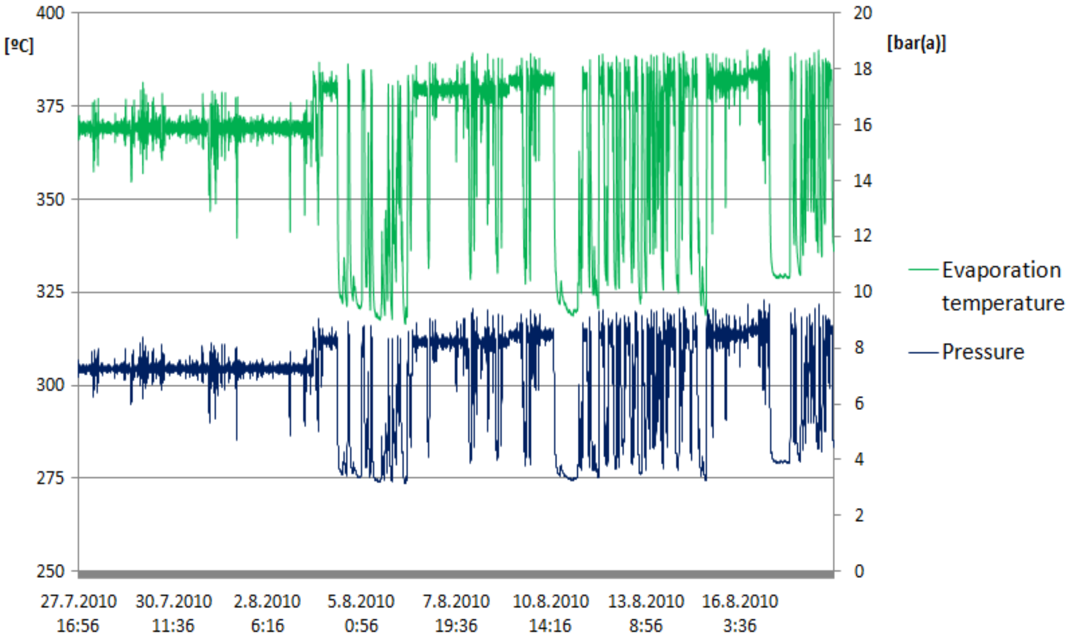


Figure 2. System pressure and cooling oil saturation temperature 27.7-18.8.2010.

The pressure fluctuations reappeared on 4th of August, but the probe pressure could still be controlled with the heating elements above about 3 bars (a). Consequently, there was no risk of departure from nucleate boiling and the associated temperature peaks.

However, electrical heaters deteriorated 23.8. so that probe pressure could not be fully controlled, see Figure 3.

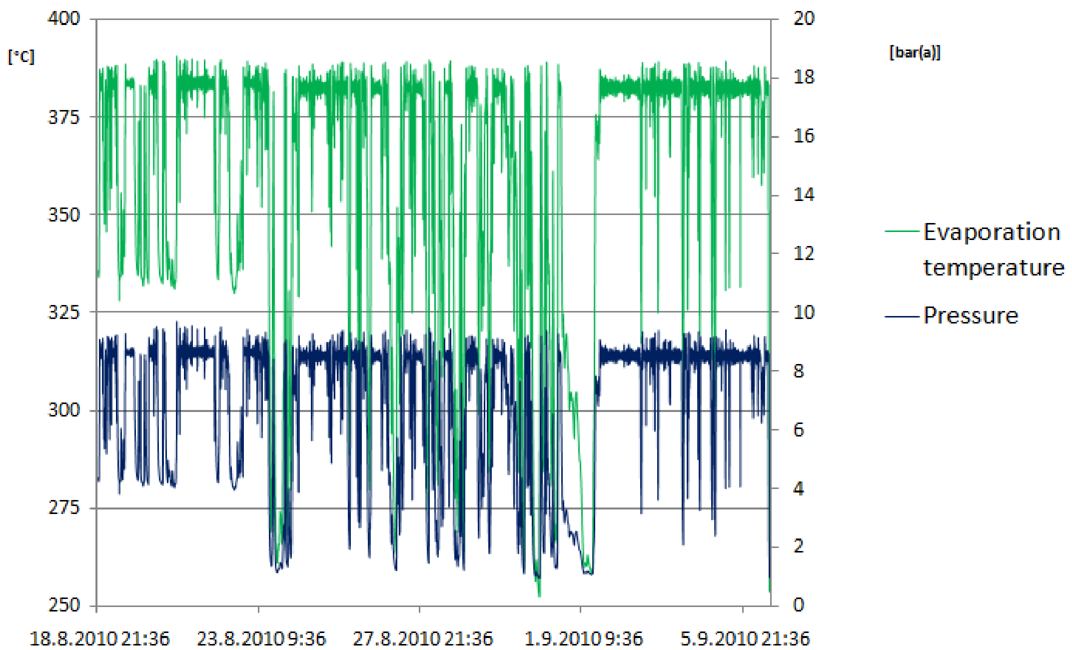


Figure 3. System pressure and cooling oil saturation temperature 18.8 – 6.9.2010.

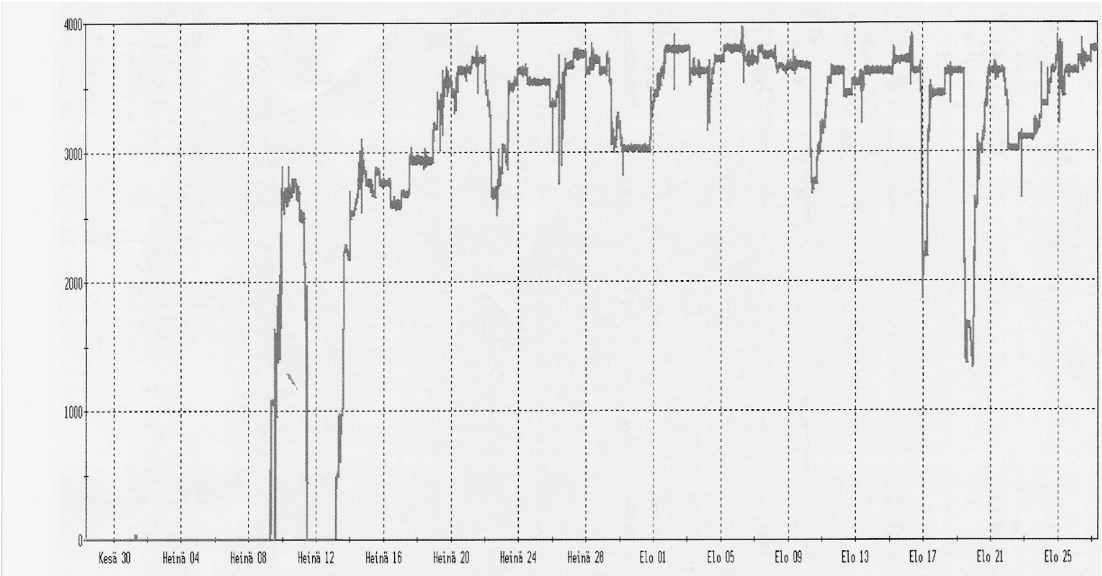
Consequently, there were about 10 – 15 instances in which the probe pressure decreased so that oil saturation temperature dropped below 300°C. In such conditions heat transfer crisis in the cooling side is possible. Should such crisis occur, test material temperatures could increase to about 600°C. Such temperature peaks, lasting 15 – 90 minutes, were experienced in few cases in the tests in the previous project.

However, in most cases the probe does not experience a heat transfer crisis even when probe pressure is low. For example, in the test no 3 in the previous project probe pressure dropped to 1 bar(a) (or below) about 40 times during the first 250 hours. Yet there was only one temperature surge, during which test material temperature increased to about 600°C for about 15 minutes, during that period.

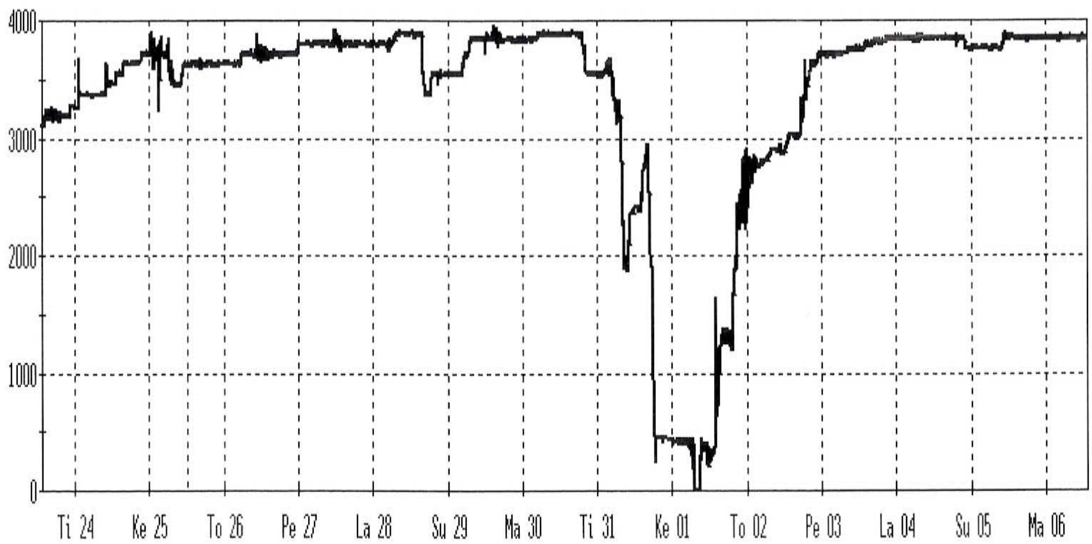
Since now there was less than 15 instances probe pressure dropped to 1 bar (a) or below, there is more than 90 % probability that no temperature excursions were experienced. Therefore it is most likely that the test was carried out as planned. Unfortunately this cannot be confirmed, as thermocouples did not function reliably at the later stage of the test, when periods of low probe pressure were encountered.

Operation of the recovery boiler during the test

The boiler load (dry solids/day) during the whole test period is shown in pictures 1 and 2. It can be seen that the boiler load stayed relatively steady with few short exceptions.



Picture 1. Boiler load during the test period between 16.7 – 25.8.2010 (tds/d).



Picture 2. Boiler load during the test period between 24.8 – 6.9.2010 (tds/d).

Summary

The test materials were recovered after an exposure of 1250 hours. However, the test material temperatures were close to the target only a portion of this time, as the probe pressure could not be kept high enough all time.

The duration the test materials were exposed to furnace conditions at high temperature was estimated by integrating the time the probe pressure was above 7 bar (a). This pressure was selected as a cutting point since the saturation temperature of heat transfer oil is at this pressure about 370°C, i.e. about 20°C more than water saturation temperature at 170 bar pressure and about 10°C less than the saturation temperature in the pressure set point of 8,5 bar(a).

The probe pressure was above 7 bars (a) for 750 hours in this test, while in the previous test the corresponding figure was 833 hours.

The heating elements used for controlling the probe pressure above a set minimum level deteriorated during the test so that the probe pressure could not be efficiently controlled during the last two weeks. During this period the probe pressure decreased in few instances to such a low level that a heat transfer crisis was possible. However, judging from the experiences gained in the previous experiments, there is more than 90 % likelyhood that no such crisis was experienced and, consequently, temperature excursions were avoided. This, unfortunately, can not be fully confirmed, as thermocouples were no longer operable during this period.