Level Gauging Measurements in Thermal Cracking Processes

Process procedure

Heavy fuel residues from various production processes in a refinery are collected and separated into lighter components through thermal cracking. Thus one gets a much better yield from heavy fuel residues; on the other hand, only petroleum coke is left over at the end of the process which may be used further, e.g. in manufacturing electrodes.

During thermal cracking the residual oil is heated up to a temperature of 430 degrees Celsius at a pressure of 22 bar and then slowly drained off from the bottom into the coker which is about 7 m in diameter and over 20 m in height, easing the pressure to about 4 bar. The heavy fuels are cracked into low and high boiling components and the gaseous light components are drained off via a nozzle on top of the coker and condensed into light mineral oil products in secondary facilities.

To fully utilize the facility's capacity it is essential, on the one hand, to fill the coker rather quickly, and, on the other hand, only so fast that the oil does not foam too much. If the foam rises in the waste gas stub pipe it would condense there and become tar or coke; within a very short time this would lead to clogging, so that costly cleaning procedures would be necessary. It is therefore very important to detect foam formation in time and to slow it down by adding anti-foaming agents.

Through optimisation of this procedure ESSO in Karlsruhe, for example, was able to reduce the filling cycle from originally 24 hours to 16 hours and to significantly improve the utilisation of the required two cokers.

If after this time the coker chamber is filled up to about 90 % of its volume, the filling is stopped and the facility switches over to the second coker chamber. Water vapor is now introduced into the full chamber from below. The remaining light components are dissolved and the still liquid container filling is cooled and transformed into solid petroleum coke. By completely filling this chamber with water it will be cooled down finally.

Large lids are now opened at the top and bottom of the coking tower and the coke is cut out using pressurized water of 300 bar. For this purpose, a central drilling, approx. 500 mm wide, is cut through the entire coker and then the coke is cut out by horizontal nozzles and transported by water to intermediate bunkers.

The top and bottom lids are closed again and the coker is ready for another production cycle. Two coking towers operating alternately are required to ensure continuous operation.

Foam and Level Monitoring

The special process conditions, i.e. pressure and temperature, the critical product properties, and the extraordinary mechanical strain when cutting out coke absolutely require the use of the radiometric measuring method.

A radiation barrier (a) has to be installed below the process gas stub pipe to monitor the

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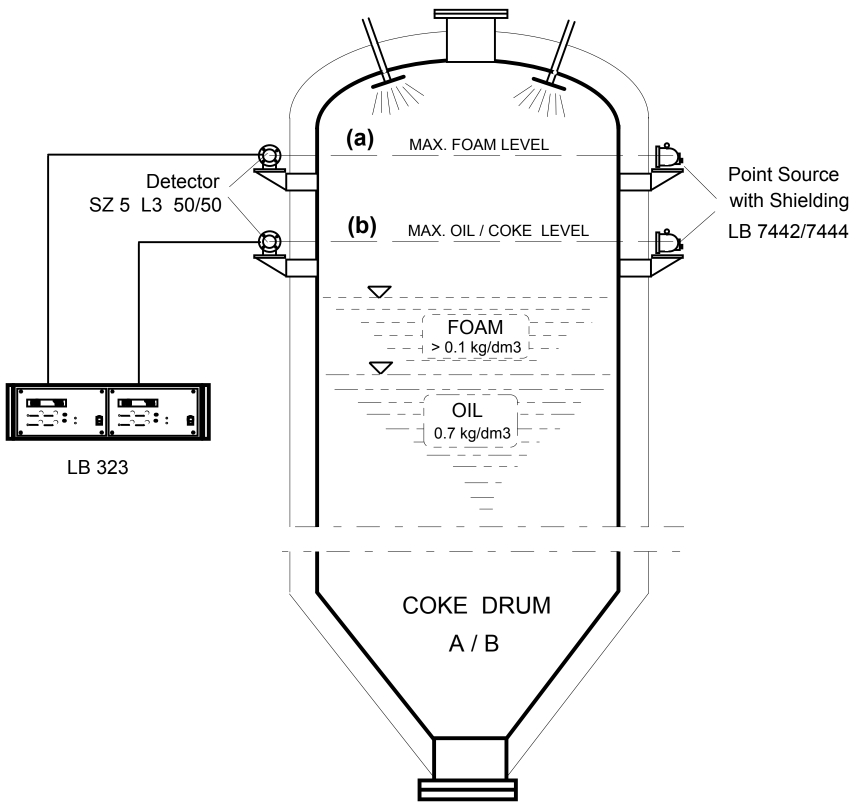
foam formation; this radiation barrier is the uppermost measuring level. A second measuring level (b) has to be installed in a suitable distance (about 2 meters) below the first level to monitor the maximum permissible oil filling. As long as the coking chamber is not filled at least up to measuring level (b), this measuring level is used to trigger a pre-alarm when the foam rises. Out of physical reasons it is impossible to distinguish between foam and liquid phases in this application directly by the measuring system. However, this is indirectly possible by observing and analysing the rising speed of the level.



Scintillation detectors are used as measuring systems in order to be able to detect foam having only a minor density; these instruments ensure a reliable measurement with a measuring effect of 20% even with foam densities of about 10 g/l. Moreover, owing to the scintillation detectors the required source activities can be significantly reduced and are often between 1 to 2 GBq Co-60 (approx.). 30 to 50 mCi).

The signal evaluation is carried out such that already with foam formation in the height of the lower measuring level actions for reducing the foam formation will be initiated and as soon as the foam reaches the upper level the foam formation is stopped by adding a sufficient quantity of anti-foaming agent. The decrease of the foam formation can be tracked on the display of the measuring system and in a printout, and the addition of anti-foaming agent can be stopped or reduced as the foam drops below the respective measuring level. If one finds at the end of the process that the foam falls only in the upper measuring level, but the lower measuring level still indicates FULL, one can assume that now the oil filling has reached that

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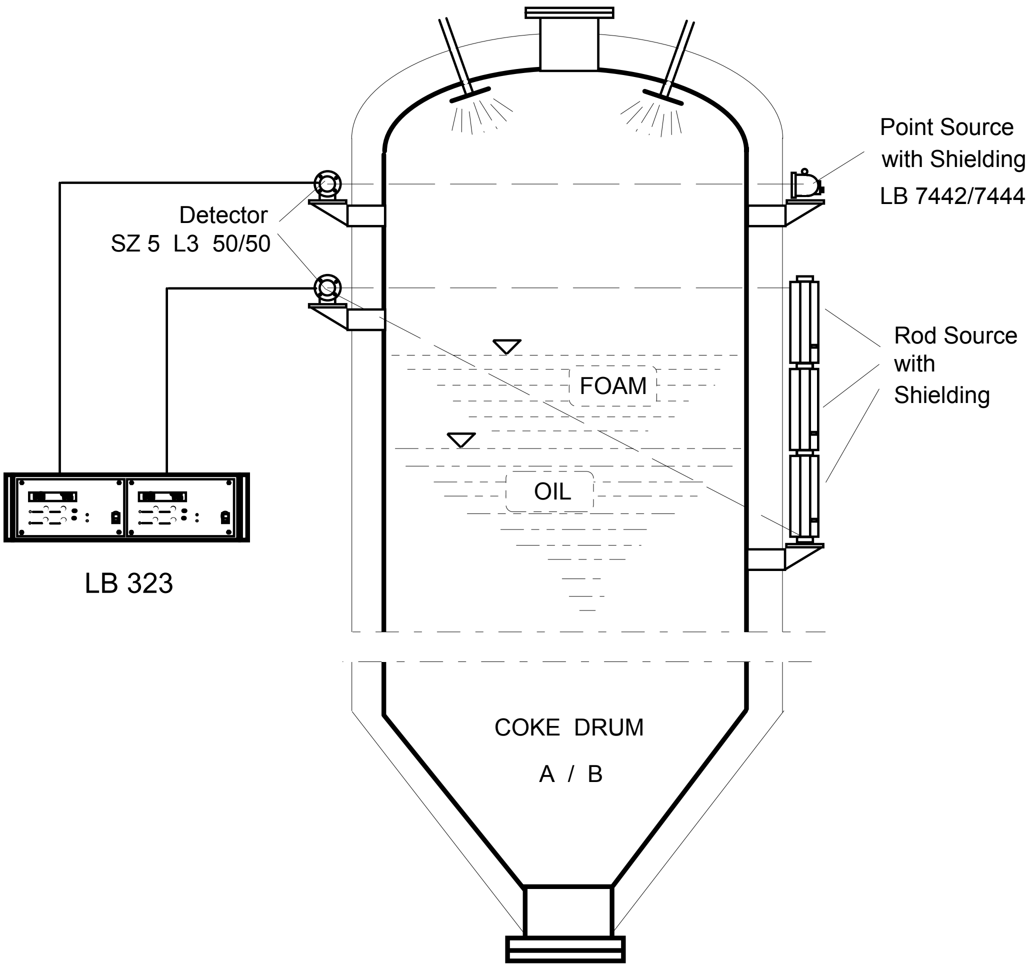
level. The filling is then stopped immediately and the system switches over to the second chamber.

Continuous Foam and Level Measurement

Since coking chambers may be up to 25 meters high it is advisable to initiate this process not at the very end of the filling; data on the foam level and the oil level over the entire last third of the filling process allow a significant reduction of the filling time, minimising the quantity of required anti-foaming agent at the same time.



Although it must be taken into account that within the foam level a density profile of heavy foam will be created directly above the surface of the oil filling level, it has been proven that the foam can be detected safely, as the foam density is given with > 100 g/dm^3. Therefore, a continuous level gauging measuring system with rod sources can be used in the usual coking chambers with diameter between 5 to 8 meters. Measuring ranges of 3 or even 6 meters below the maximum filling are monitored. For the larger ranges the level measuring

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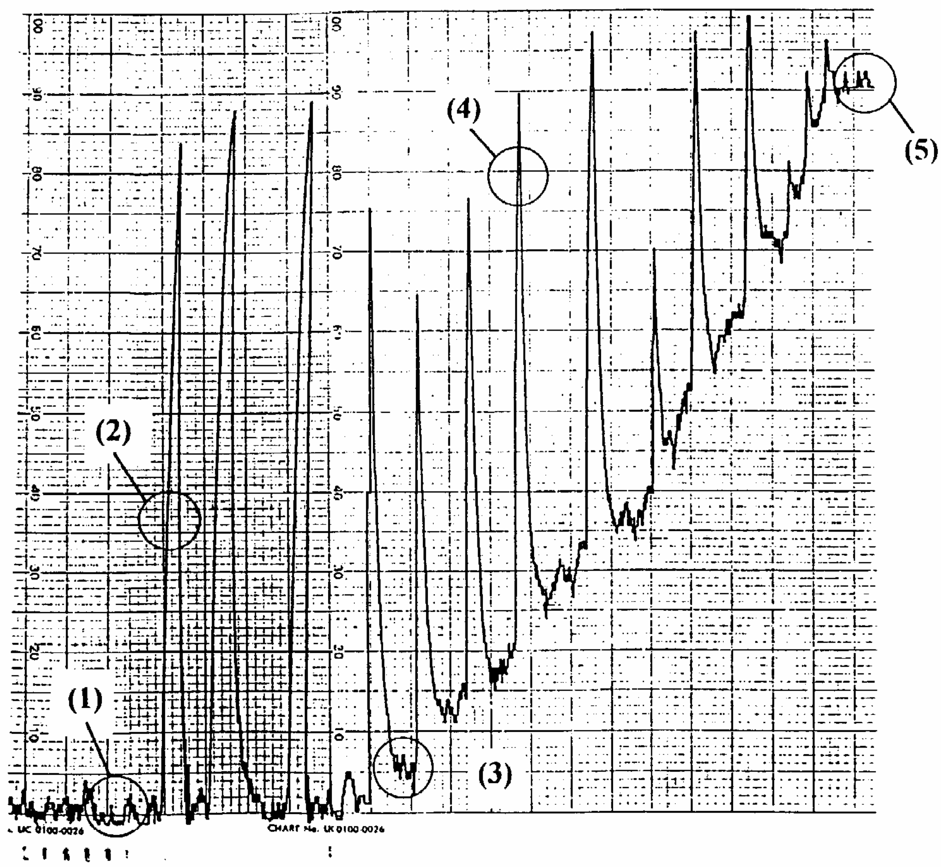
devices are being divided into two groups which gives the possibility to enlarge the total range by using a gap of 1 ore two meter between the two continuous measuring groups. Out of physical reasons the measuring system cannot distinguish between foam level and oil filling level. However, this is indirectly possible by observing the rising speed of the level or analysing the data on the printout.

The continuous level gauging measurement immediately indicates when foam is being produced which rises up to the range of the measuring system. As soon as a certain level is reached, anti-foaming agents are added and the effect of this action can be tracked on the display. The printout clearly shows when the oil level rises up to the range of the measurement, since then, after the addition of anti-foaming agent, the display contribution due to the foam level will go back only up to the level of the oil filling.

The printout shows, for example, a filling level below the measuring level (1). Then the foam rises up to the measuring range (2) and immediately collapses after adding anti-foaming agent. This repeats several times until at last the indication does not go back to EMPTY any more (3). This means that in the meantime the oil level has risen up to this level. Even though foam formation is detected occasionally (4), a distinction between foam and oil level is now possible. The filling process stops as soon as the oil filling has reached the maximum level (5).



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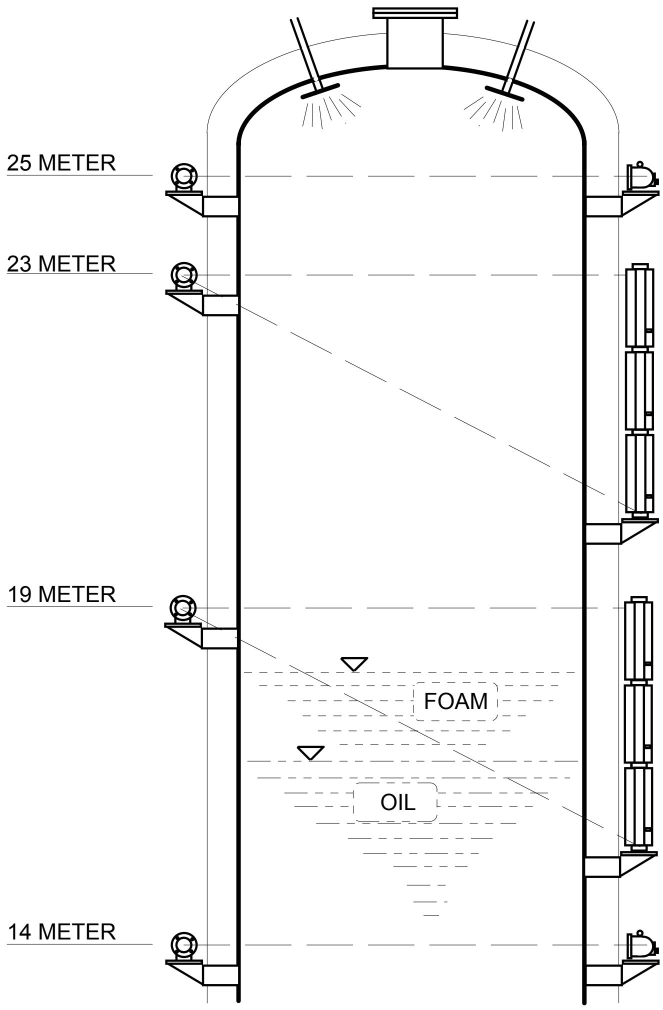
If a continuous and gradual addition of anti-foaming agent is started at a certain level, one can reach maximum filling speeds with little or no foam formation. In this manner one can cut the process cycle to a very short time.

In any case a radiation barrier below the process gas stub pipe is required for safety reasons. This radiation barrier is also used to monitor the complete filling with water up to this level which is required at the end of the process.

The use of an additional radiation barrier is advisable in the bottom third of the coking chamber as well in order to detect possible foam formation at the start of the filling phase and to know exactly when the oil filling has reached this point.



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Measuring equipment required

Scintillation counter detectors with maximum sensitivity have to be used as continuous level gauging systems. Due to their high detection sensitivity scintillation counter detectors should also be used as radiation barriers and only with this kind of detector the foam density of 10 g/dm^3 can be monitored. Since detectors with high sensitivity are superior due to the lower source activity required, it is in addition economical for spare part stock keeping to select detectors of the same type. We recommend using the Level Gauge LB 323 and Sz5-L3-50/50 detectors, together with the appropriate point and rod sources.

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