Expert Report

Cold starting shell boilers

Prof. Dr.-Ing. Eberhard Franz, sworn Expert in Steam Generation and Energy Process Engineering from the Nuremberg Chamber of Commerce and Industry for Central Franconia

1. Introduction

Cold starts place a much greater mechanical load on shell boilers than normal operation. A cold start is unavoidable the first time the boiler is commissioned. However, procedures similar to cold starts can also occur after initial start-up, e.g. after the boiler has been left idle for some time or in the case of multiboiler units with sequencing control without pressure and temperature maintenance. They are characterised by the fact that the water in the boiler does not boil. For example, the water at the first start-up has a temperature of around 20°C and is thus some 80K colder than water boiling at an absolute pressure of 1 bar.

The reason for the higher mechanical load during cold starts is the temperature difference between the flame tube and the boiler shell, which is much higher than in normal operation. For this reason, the flame tube expands more in relation to the boiler shell than in normal operation. This creates, between the flame tube and the boiler shell or the flame tube and colder flue pipes, a considerably increased mechanical load on the relevant connecting and fixing elements, such as flame tube/floor connection, anchor tubes, flame tube/reversing chamber joints, corner anchors, etc..

The following shows, in the first place, calculations for the temperature difference between the flame tube and boiler shell and then summarises and evaluates them.

2. Calculating the temperature difference between the flame tube and the boiler shell during a cold start.

The average flame tube temperature was calculated using a simple calculation model. The following practice-based assumptions were made:

> The heating process is carried out initially with the steam valve open at an absolute pressure of 1 bar. The temperature of the boiler water is 20°C to start with and then increases on a linear basis with time until boiling point is reached (phase 1).
>
> After this, the heating process is carried out with the steam valve closed. The pressure increase was assumed to be 1bar/min, which corresponds to the normal pressure rise in a shell boiler at full burner load and with a closed steam valve (phase 2).

The calculation was carried out for various burner loads during the first phase, and 100% burner load was assumed in the second phase.

The shell of a shell boiler has more or less the temperature of the boiler water. It is therefore subject to a much smaller temperature-related expansion in length than the flame tube, which is intensely heated by the burner flame. The temperature difference between the average flame tube temperature and the boiler shell temperature is thus a measure of the difference in lengthways expansion between the flame tube and the boiler shell. The differences in length deformation, also known as "Flame tube thrust", must be absorbed by the connection elements.

On the basis of the high burner load, it takes only around 500 s until the water in the boiler reaches boiling temperature. What is interesting is the line of the temperature difference. It reaches its maximum at 115 K. This is 2.5 times the value in normal operation (46 K). In other words: flame tube thrust during a cold start at 100% burner load in phase 1 is up to 2.5 times as much as in normal operation. It must therefore be assumed that the mechanical loading on the shell boiler is considerably increased. The only possible way in which the boiler operator can influence this is to reduce the burner load in phase 1.

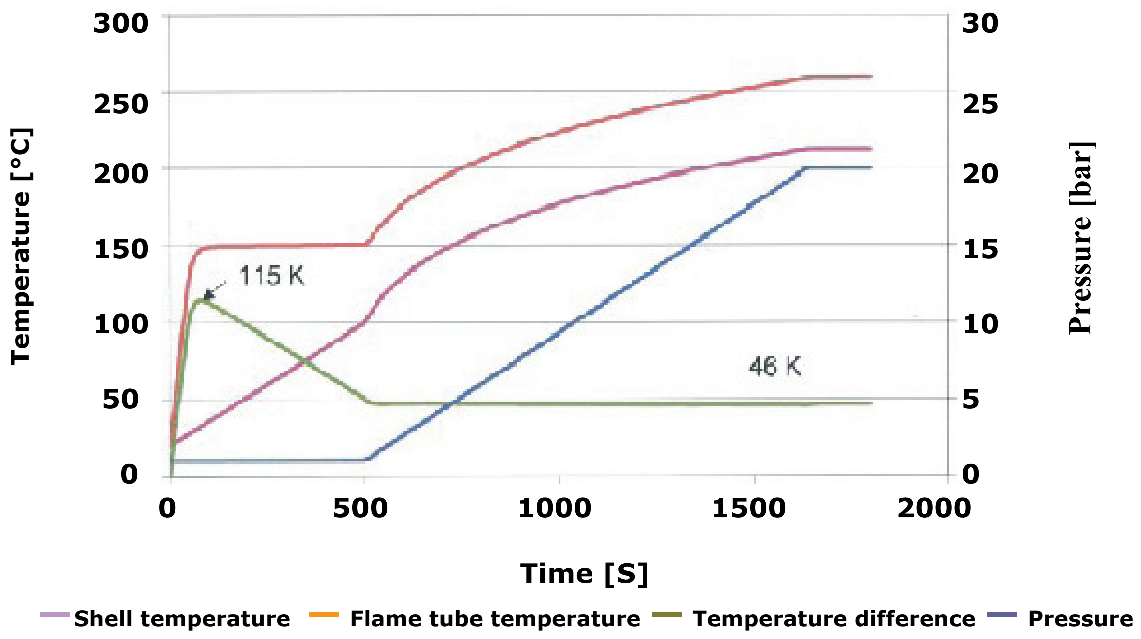

Fig. 1 shows the result of a calculation with 100% burner load in phase. Above the time, we show:
· the temperature of the boiler shell,
· the average flame tube temperature,
· the difference between them,
· the absolute boiler pressure.

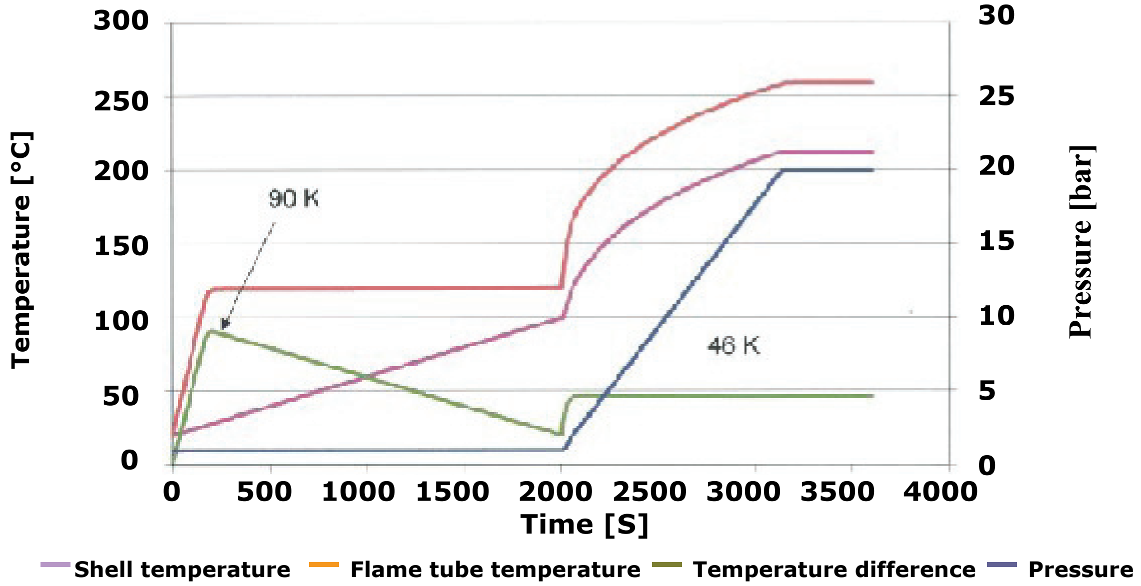

Figure 2 shows the situation for 25% burner load in phase 1. Because of the reduction in heating, it takes 2000 s, until the boiler water boils. The maximum temperature difference between the boiler water and the flame tube is 90 K, which is still 1.96 times the value in normal operation.

Summary

Cold starts cause a much greater mechanical load than normal operation. They should be carried with the lowest possible burner load until boiling point is reached. However, it should be noted that even with a burner load of only 25%, the maximum flame tube thrust is almost twice the stationary value. For this reason, procedures similar to cold starts should be avoided as far as possible after the first unavoidable cold start.
In order to ensure operation without damage, we strongly recommend that systems which only operate on a temporary basis and with long idling phases (e.g. not operating at weekend, or redundant systems with sequencing operation. control) are fitted with a state-of-the art pressure and temperature maintenance device.
Bron: www.loos-int.com