

AUTOMATIC SUGAR DETECTION IN BOILER FEED WATER

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Introduction

At most sugar factories where condensates are used as boiler feed water, this liquid is regularly analysed for the presence of sugar. Not only because its presence indicates an increase in undetermined losses, but more so because of its detrimental effect on the boilers.

In the alkalinized feed water, sugar tends to decompose into sugar acids and other products which lower the pH and in this way increase the rate of corrosion of boiler tubes. In addition, the boiler water has a tendency to foam, which results in a carry-over of salts in the steam.

The presence of sugar in condensate is often not continuous, but occurs for short periods only, at irregular intervals. For this reason, the testing of feed water must be carried out very frequently if it is to be effective, and a continuous automatic analyser would therefore provide a much better means of control than analysis carried out intermittently.

Various Methods of Analysis

For the detection of a chemical compound, one of its characteristic chemical or physical properties is used. Sucrose is normally determined by its optical rotation, but unfortunately this method is not suitable for the detection of very small quantities.

For automatic analysis, it is generally more convenient to use a physical rather than a chemical method, because in the latter, other chemicals are always necessary.

For this reason, the conductivity of the boiler feed water is used in a number of automatic analysers to trace the presence of sugar, although sucrose in small quantities does not affect the conductivity of a solution.

In sugar factory liquids, sucrose is always accompanied by a certain amount of impurities. These impurities increase the conductivity, which is easily measured and can be used to operate an electrical warning signal or an electrical valve.

This method, however, will be far less sensitive or fail completely, if the sugar to be detected in the water originates from carry-over of high purity massecuites in the condensate. On the other hand, a high conductivity can be found to originate from salts in the condensate without sugar being present.

A better method is a reaction on the sucrose itself, which however, requires a chemical analyser. A chemical analyser is more complicated and requires higher maintenance costs and in the second place, it uses chemicals thereby increasing running costs. Furthermore, it requires supervision at frequent intervals.

The Principle of a Chemical Analyser

A sample is withdrawn intermittently or continuously from the feed water line and one or more chemicals, depending on the chemical reaction chosen, are intermittently or continuously added in the required proportion.

The chemical reaction results in the formation of a precipitate or colour formation, and this result is converted into an electrical signal by a phototube, photocell, phototransistor or a photoresistor.

This signal is amplified and can be used for the operation of an electrical valve in the same way as instruments which measure the conductivity.

One of the older colour reactions for sucrose is brought about by the addition of concentrated sulphuric acid in the presence of a phenol, the most commonly used being *o*-naphthol.

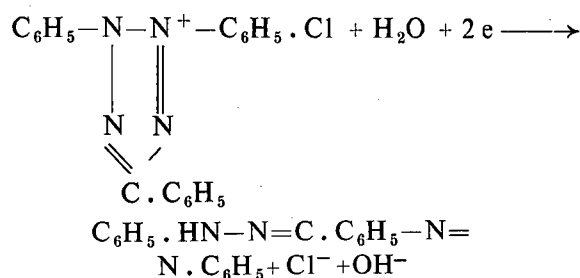
In the event of sugar being present, even in small quantities, a blue colour is formed.

An automatic sugar detector can be based on this reaction, but a disadvantage of the system is that rather large amounts of concentrated sulphuric acid, which is an unpleasant chemical to handle, are required by the instrument.

Work Carried Out by the S.M.R.I.

For about the last ten years, a very sensitive colour reaction for reducing sugars has been known, which is fairly specific.

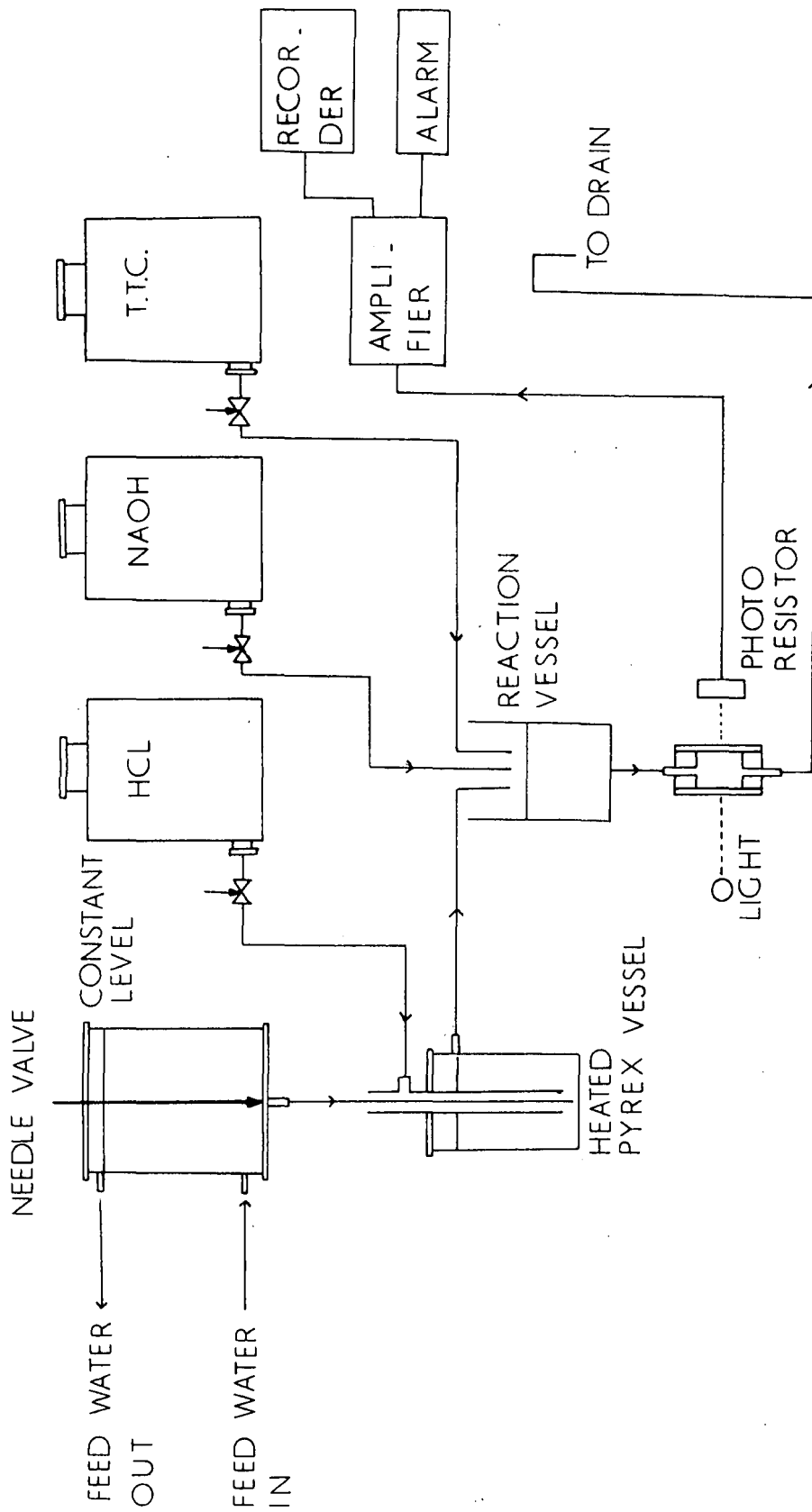
If a colourless alkaline solution of triphenyl tetrazolium-chloride solution is heated with a reducing sugar, red triphenylformazan precipitates.



In contrast to most other reactions for reducing sugar, the majority of other reductants do not interfere. Aldehydes, hydrazine, hydroxylamine, sulphites, tartaric and citric acid are inactive towards the reagent.

When employing this reaction for the determination of sucrose, the sucrose solution to be used first has to be inverted by heating with acid, then the solution has to be made alkaline for the colour reaction.

An experimental model automatic sugar detector, based on this principle was constructed in accordance with details published by the British Sugar Corporation.¹ In this first model, sample and chemicals were combined intermittently by the opening of small



valves connected to a camshaft driven by a synchronic motor at a speed of three rotations per hour. Thus, three samples were analysed each hour. This instrument was installed at Sezela for testing under factory conditions.

It proved to be insufficiently reliable, however, and furthermore, the pyrex glass vessel used for heating, could not withstand the continuous changes in temperature which occurred when cold and boiling solutions were run into the vessel.

A second model was so constructed that the sample of feed-water was continuously fed from a constant head vessel into the pyrex heating beaker by means of a small needle valve. As in the first model, the three chemicals were fed by gravity from aspirator bottles, but in the case of the second model, these were introduced into the instrument by means of perspex needle valves. Of the various photo-sensitive elements tried, a light-dependent resistor was not only the cheapest, but also the most sensitive.

The operation of the instrument is as follows:

The feed water drips from a constant head vessel into a pyrex vessel placed at a lower level and provided with an overflow tube. In this vessel it is heated and mixed with hydrochloric acid, and the mixture flows upwards into the overflow tube.

The size of the pyrex vessel and rate of flow of the water were so selected that the retention time in the vessel would be ten minutes, which is sufficient for

inverting the sample. The time of operation from start to finish of the testing of a sample is fifteen minutes.

The heated mixture flows through the overflow tube into a reaction vessel, where 10 per cent NaOH and 0.1 per cent T.T.C. are added. If sugar is present, a finely divided red precipitate is formed, which influences the transmittance of light through the cuvet. This results in a proportional increase in the resistance of the light-dependent resistor and is converted into a voltage increase, which is amplified and can be read on a mA meter, or can operate a relais for a warning signal, or an electric valve.

The sensitivity of the instrument is in the vicinity of 10 p.p.m. sucrose.

The provisions for drainage of the instrument are so arranged that the cuvet never runs empty.

This second model has been working at Hulett's Refinery on trial and its operation has proved to be reliable. A few minor alterations will be necessary.

In the mean time, however, an instrument operating on the same chemical principle has been placed on the commercial market by a British firm, Messrs. William Boby & Co.²

In view of this fact, the need for further research on this subject seems questionable.

References.

- ¹ Parker, Int. Sugar J., 60 (1958), 71.
² Sugar y Azucar, Oct. 1961, 37.

(For discussion on this paper see page 55)