REPORT

WORK CARRIED OUT ON COLLOID-A-TRON WATER TREATMENT UNIT

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DEPARTMENT OF MECHANICAL ENGINEERING
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INTRODUCTION

This is a report on the work carried out on the Colloid-A-Tron at U.C.D. Engineering School during the period August 1984 to March 1985. The work was carried out in conjunction with Fluid Dynamics Limited of Sandyford Industrial Estate , Dublin the manufacturers of the equipment.

The work was first pursued as a summer project and was continued as part of the final year term work - a fourth year project for a B. Sc.

The Colloid-A-Tron (C-A-T) is a non-chemical water treatment device. It consists of a torpedo shaped core which is placed in a cylindrical casing. This casing is of the same diameter as the pipe carrying the water to be treated. The core is an alloy. Metals are present in the core in precise quantities.

The turbulence bars which are on the surface of the C-A-T cause an increase in turbulence of the water passing over the C-A-T. This turbulence increase is thought to be important for the effi cient operation of the C-A-T.

The C-A-T has an effect on the scale formation pattern in almost all of its applications and it works quite well in most of these applications. However, it sometimes has an insignificant effect and occasionally it appears to have no effect whatever.

Earlier research work has already been carried out on the C-A-T with the object of examining its' effect on scale formation under controlled conditions. This work includes:

(a) THE SULZER REPORT

This is a report on work carried out by the Sulzer Company of Switzerland. The object of the work was to evaluate three types of non-chemical water treatment devices. The C-A-T was one of these devices. The apparatus used was a boiler circuit. The feed water was treated by using a C-A-T.

Scale to be examined was removed from the boiler surface. The scale formed when a C-A-T was present was compared to that formed when no treatment was used.

The work indicated that :

(1) No reduction in total water hardness level occurred.

(2) The C-A-T reduced the volume of scale formed by approximately 50%.

(3) Repeated passing of water over the C-A-T seemed unnecessary. Better results were obtained with a single pass.

(4) Scale formed when a C-A-T was present was less hard and more porous than scale formed when no treatment was used.

(5) Of the three devices tested, the C-A-T gave the best all round results.

(B) THE TRINITY REPORT

This is a report on work carried out at Trinity College, Dublin, with the object of determining how the C-A-T functions and where it functions most effectively.

The apparatus used was a heating element inserted in a small tank, from which water flowed into a larger tank. The feed to the small tank was arranged in such a way as to allow a C-A-T to be placed in the circuit. The scale to be examined was removed from the heating element.

The work indicated that :

(1) By increasing the heating element temperature, more scale formed.

(2) At low P.H. little scale formed but as P.H. was increased, scale formation proceeded more rapidly.

(3) As the flowrate over the heating element was increased, the scale formation rate also increased.

(4) The scale formed when a C-A-T was present in the circuit. Scale was softer and more porous than that formed when no C-A-T was present.

(5) No detectable metal leaching occurred when the C-A-T was in operation.

DESCRIPTION OF THIS WORK

The work carried out concentrated on formulating a testing method which could indicate whether the C-A-T would work in a particular application or not. To do this, the C-A-T was looked upon as a "black box", the object being to determine what the C-A-T did rather than how it did it. The result of this approach was a testing procedure capable of determining whether or not the C-A-T would work on a particular water type. The establishment of such a procedure was more useful to Fluid Dynamics than an in-depth analytic study of the subtle effects caused by the C-A-T.

OBJECT OF THIS WORK

Initially the preliminary object of the work was the design of a heating element which could be easily removed from the experimental set up to allow examination and evaluation of any scale formed.

When this was achieved the next object was the construction of a test rig on which the performance of the C-A-T could be evaluated under controlled conditions. A further object was the design of a test apparatus based on findings from the experimental test rig. This test apparatus would be for use by Fluid Dynamics for determination of the effectiveness of a C-A-T on a particular water type.

A preliminary flow system was developed for the evaluation of different types to measure scale formation but this flow system did not allow sufficient control of flow and water temperature to justify it's use as a flow system for the evaluation of a C-A-T. The design of an experimental flow system was now undertaken. Such a flow system was required to allow the introduction of a C-A-T into the system. It was also required to allow a test to be repeated in order to establish a comparison between tests.

Tests on the preliminary flow system had indicated some difficulties which might arise while operating a flow system. A method of flow control was needed because the flow through a system can vary during a test.

Flow is a critical parameter because if the flow is too high a large cooling influence on the filament arises causing it to show a reduction in the rate of scale formation. If the flow is too low, total evaporation of the water passing over the filament can occur, causing the filament to fail due to overheating. This occurs because steam does not remove nearly as much heat from the filament as water does. When using a certain power input into the filament it is necessary to determine the optimum flow for this power input. The flow must be neither too high nor too low. The temperature of the water leaving the filament is a good indication of whether the flowrate is correct or not.

A temperature of 85 C of the outlet water is the optimum temperature. Below 85 C the flow is too high and is having too great a cooling influence on the filament. Above 85 C, the water is too hot and danger of total evaporation occurring exists. Another problem with the flow system is that the filament causes a significant increase in water temperature. This is not a great problem when dealing with 10L samples as the 10L samples supplied sufficient fresh water for the deviation of a test. However, in the experimental flow system, smaller sample volumes were to be used, of the order of 1 litre. This meant that many passes of the same water over the filament would occur. A method of heat removal from the water was needed. Therefore the introduction of a cooling coil was necessitated.

A practical method of introducing a C.A.T. into the system needed investigation. The use of an actual C-A-T was not practical as the flow in the system would be much lower than any flow used in practical systems. A method of placing a C-A-T in the system and obtaining the same turbulence levels as those obtained in an industrial application had to be devised.

The following experimental flow system was devised to overcome these difficulties.

(1) A Sample Jar: A 2.5 litre sample jar is used. A sample to be tested is placed in this jar.

(2) A Pump: A gear-type constant displacement pump is used. The pump is powered by a D.C. motor, supplied by a variable D.C. power supply.

(3) The flowmeter: This flowmeter is a rotameter - type flowmeter. It is used to monitor the flowrate in the system. It can measure a flowrate in the range 0 to 350 ML/minute.

(4) The filament: The filament is a coiled tubular type filament

(5) The A.C. power supply: This power supply comes from a variae which transforms the A.C. supply at the socket to the supply type required for a given test.
This power supply is monitored using a voltmeter and an ammeter. The voltmeter can measure from 0 to 70 volts and the ammeter can measure from 0 to 50 amperes.

(6) Two thermometers: One is placed in a vessel at the filament outlet. This allows the water temperature at the outlet to be monitored, giving an indication as to the suitability of the flowrate for a given power input. The second thermometer is in the sample jar and this ensures that the sample is at constant temperature i.e. that the cooling coil is operating effectively.

(7) The cooling coil: This is a counter-flow cooling coil. It consists of a coil of tubular copper placed in an outer casing. The sample water flows through the copper coil, tap water flows in the opposite direction through the outer casing, cooling the water in the copper coil.

In the flow system water flows from the sample jar, into the pump and through the flowmeter. It then flows into the filament, where it is heated and forms scale. It then passes through the thermometer vessel and onto the cooling coil where it is cooled. It is then returned to the sample jar.

In order to find the optimum operating point for the flow system, a calibration test was carried out. The flow rate was set at a certain value and the power input was increased until the optimum operating point for that flow rate was established. The power input needed to obtain a good boiling action on the filament decreases as the flow rate decreases. This is as expected. A value of 85 C for the outlet water temperature seems to indicate that the best boiling action is occurring on the filament. At this water temperature the power input is still below the critical value above which total evaporation of the water can occur

Using the calibration data it was decided to select a flow rate of 150 ML/min and a power input of 744W for future tests. This gave a temperature of 84 C at the outlet in the 150 ML/min test. The system behaved in a stable manner when these parameters were used.

The method used to introduce a C-A-T into the system was to construct a stirrer made of C-A-T metal alloy. This would be placed in the sample jar and rotated at a speed which gave a turbulence value over the C-A-T equivalent to that found when a C-A-T was used in an industrial application. A pattern for such a stirrer was made in the pattern shop of U.C.D. Mechanical E ngineering Department. This pattern was then delivered to FLUID DYNAMICS for the casting of a number of the C-A-T stirrers. The CAT stirrers were cast with turbulence bars equivalent to those on an actual C-A-T. A computer analysis of the effect of a C-A-T on the turbulence in a pipe was prepared in order to calculate the speed of rotation needed to give an equivalent turbulence over the C-A-T stirrer to that found over a small C-A-T in an industrial application.

It is not known if the stirrer models a C-A-T in industry sufficiently accurately. The results obtained on actual samples would tend to suggest that it does.

A series of tests were undertaken on the experimental flow system.

In Test Series 1, four batches of water of varying hardness levels were analysed. All four samples, when analysed, demonstrated a weight drop. Three samples demonstrated a weight drop of over 40%, the fourth showing a weight drop of 8.5%. No explanation could be put forward to explain this low weight drop but it may be due to some error unaccounted for in the system.

However, a weight drop did occur in each case and this is very significant.

The amounts of scale formed in each case was low. Large errors can arise when weight differences of 0.3 mg are being dealt with on a balance that weighs to 0.1 mg. To increase the overall amounts of scale formed in a test, the sample volume was increased in subsequent tests.

In Test Series 2, the same batch of water was used in all tests. A total of 5 tests were carried out, two with a C-A-T. The results are shown on Fig. 5-D. A significant weight drop was observed in the cases where a C-A-T was used. The use of the 1 litre sample volume caused larger scale amounts to be deposited and made the weight determination process less susceptible to error.

In Test Series 3, water from Coca-Cola in Tuam, Co. Galway was tested. There is a C-A-T in operation at this site and it works well. In this test series a weight drop of 64.6% was observed, the largest weight drop observed in any of the test series. The scale formed when no C-A-T stirrer was in operation and the scale formed when a C-A-T stirrer was in operation were examined using electron microscopy.

In Test Series 4 water from North Dublin was analysed. A number of C-A-Ts are working well on this water. However, when this water was tested, the amounts of scale formed and the weight drops were low. This may be due to the fact that the container in which the sample was supplied was contaminated. An organic substance, possibly lubricating oil was seen to be floating on the surface of the sample. The container, when opened, had a strong odour of petrol. However, a weight drop was observed, indicating that the C-A-T did have an effect.

In some cases the experimental flow system yielded some results which were not as expected i.e. batch 8 water in Test Series 1 and Test Series 4. In order to average out such spurious errors and to prove that the procedure is a valid testing method, a greater number of tests must be executed on water from C-A-T applications. Statistical methods could then be applied. The magnitude of the percentage weight drop may then be found to bear a relationship to the effectiveness of the C-A-T in an application. In Test Series 4 a large weight drop was observed on water from an application where the C-A-T which is in operation works very well. In Test Series 4, even allowing for contamination of the specimen, as large a weight drop would not have been observed. This would indicate that the C-A-T does not operate quite as well on this water type. THE TESTS ON BOTH SYNTHETIC AND ACTUAL WATER TYPES ALL INDICATED A WEIGHT DROP.

This would lead one to conclude that the experimental flow system is a valid method of C-A-T evaluation. How much can be further drawn from such results remains to be seen. At present, one can say the C-A-T will work but one cannot as yet say how well it will work. Further testing must be done before this objectiv is attained.

It is clear from the results that the filament itself suffers a weight drop due to the use of acid as a cleaning agent. The effect of acid attacking the wire surface has not been evaluated. However, comparison of the results obtained in tests where no C-A-T stirrer was used indicated comparable weight quantities. This would seem to indicate the effect of an acid attack on the filament wire is neglegible.

The decrease in the hardness level of post-test water compared with pre-test water is not due to an effect caused by the C-A-T. It is due to the removal of scaling material from the sample by the filament. A sample volume must be large enough to render this effect negligible in a test.

Five series of tests were carried out using the experimental flow system.