Effects of Water Constituents on Textile Mills Production and Boilers Efficiency, Gezira State, Sudan

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ABSTRACT

Water, the raw material for making steam, contains various types and amounts of impurities. Completely pure water, although desirable for steam generating systems is non-existent. When water is boiled into steam its volume increases about 1600 times, producing a force that is almost as explosive as gunpowder. This causes the boiler to be extremely dangerous equipment that must be treated with utmost care. This paper studied the effects of water constituents on boilers efficiency and textile mill production. Samples of water were collected from two different locations namely from Blue Nile Textile Company and Gematex Textile Company, which are located in the Gezira State, Sudan. Chemical analysis, such as: total dissolved solids (TDS), pH value, electric conductivity (E.C), carbonates (CO_3^{-2}) and bicarbonates (HCO_3^{-1}), calcium ion (Ca^{+2}) and temporary hardness were carried out. The obtained results showed that samples of the boiler feed water for the two factories constitute various anions and cations with varying degrees. The boiler may be deficient and the cost of running will be high. It is recommended for more certainty that these constituents should be removed totally from the water. All recommended processes in the pipe line to condition the boiler feed water should be adopted and maintained perfectly before the water enters the boiler to avoid serious limitations.

Keywords: Water Constituents, Boilers Efficiency, Steam, Textile Factory, Hardness, Treatment

INTRODUCTION

The use of boilers that work under pressure in industrial organizations is increasing. Some boilers are used for the generation of steam in power stations and others are used for heating, A boiler is an equipment for steam generation and it consists of two principal parts namely the furnace, which usually provides heat through the burning of a fuel, and the boiler itself which is a device responsible for the heat change of water into steam. The steam is then re-circulated out of the boiler for use in various processes in heating applications. Proper treatment of boiler feed water is an important part of operating and maintaining a boiler system and any contaminant of concern should be controlled or removed through external or internal treatments in order to protect the boiler from corrosion or other unwanted adverse effects, Jami et al, (2013).

Steam is used in most types of textile industries; sometimes to ensure the product quality parameters, other times to assist the utility of machineries, such as chillers. Chemical processing of textile, such as preparation, dyeing and finishing is important for its additional value to fashion and function. However, these processes are water, energy and chemical intensive, Kartic, and Gopalakrishnan, D. (2014).

Wet textile processing industry requires significant quantities of water and heat energy. Heat in the form of steam, which is generated by boilers, is widely used for unit processes and chemical operations. For textile chemical processing steam is used for fixation of chemicals, dyestuff, finishing agents, and for drying of textile materials, Mishra, (2010).

Industrial reuse has increased tremendously since the early ‘90s for most of the same reasons urban reuse has gained popularity, including water shortages and increased populations, particularly in drought areas, and legislation regarding water conservation and environmental compliance. To meet this increased demand, some countries have increased the availability of reclaimed water to industries, and have thus alleviated the demand stress on fresh water supplies, Jami et al, (2013).

It is a matter of pity that, steam is often considered free and its use is not done in an efficient way. Most probably, the availability and relatively low cost of natural gas are behind such ideas. Condensate, process water & dyeing water are drained, which can be reused Cutenberg, (2011).

According to Easton and Mc Conky, (1958), the purpose of any power plants is the power output which should be obtained as economically as possible consistent with capital cost and running conditions. It is necessary to assess the overall performance of a plant for comparison purposes and the important criterion is the overall thermal efficiency. In a plant it may be needed to assess a boiler or steam generator only in which case the boiler efficiency may be defined by the heat transmitted to the working fluid compared to the fluid energy supplied.

Many African countries produce textile raw materials of high quality, for example, cotton. The emergence of a textile industry can have a multiplier effect on their economy. The textile industry is capable of serving as a poverty reduction establishment, employing people on the farm, factory and garment production units. Additional people will be employed as distributors and merchants in textile materials and clothes, Alnagaawi, (1980).

During the early days of water reclamation for industrial reuse, there were no regulatory policies governing water quality; all the existing regulations then were focused on the reuse for potable purpose. However, as water reuse spread across the industries, the regulations that began to spring up for specific industrial reuse are now becoming more and more stringent– USEPA, (2004). Optimization of industrial steam systems represents one of the largest non-processes, industrial energy opportunities, with improvements of 30% readily achievable in typical plants through the introduction of a best practice approach for understanding the steam system. To optimize a steam system, the plant must be integrated as much as possible so that one operating area's excess steam can eliminate the deficit of steam in another area. To eliminate the excess steam condition, all sources of steam that contribute to the excess steam condition must be identified. If it is not possible to eliminate excess low-pressure steam, then effectively utilizing the steam is the next best alternative. Repairing steam leaks and insulating equipment is also important at steam boilers. Textiles (dyeing and printing) are energy intensive industries. In the face of rising costs and increased competition, efficient utility management is a major focus area in these industries, Vorosmarty, (2010).

In this paper, a study will be conducted in selected textile factories to analyze the direct impact of boiler blow down, condensate and waste water heat recovery on fuel consumption. As a part of study, boiler blow down, condensate recovery and waste water that is disposed to sewage were included in the study. In all the factories, their main investment is in the steam production. As the industrial sector continues efforts to improve its energy efficiency by reducing heat losses provides an attractive opportunity for performance optimization of the boiler. In any case if the boiler is to use more fuel than entitled for, due to reasons associated with the constituent of the boiler feed water, then this phenomenon will constitute a serious limitation to the performance of the process. The water required for boiler feed purposes i.e. for steam generation, should be of high quality and require a lot of treatment before use. Boiler feed water containing mineral particles may be responsible for serious limitation on the performance of the steam boilers due to corrosion and scales formation. This article should motivate others to undertake extensive research work to find out the optimum solution for textile industries in Sudan.

MATERIALS AND METHODS

Water samples:

The water samples were collected from each location for chemical analysis. The locations were textile factories.

a. Blue Nile Textile Company, Wad Medani City.
b. Gematex Textile Company, East Wad Medani.

Three containers of two litres in each case were collected to ensure full representation of the samples to the whole bulk of the water. The samples were collected In intervals i.e. at the beginning of every working shift. The first samples were taken from the tank fed from the water source, river or well i.e. before treatment. The second samples were collected after the water being treated i.e. after treatment.

The instruments used in the titration and determination of the constituents of the boiler feed water samples were: Burette, pipette, volumetric flask 250 ml, flasks, beakers, weighing balance and steam bath. The pH, total dissolved solids (TDS), electric conductivity (EC), values were determined by microprocessors.

Each sample was tested three times for every chemical check. The average value of the three test results was then calculated.

Testing:

1. Total Dissolved Solids (TDS):

Total dissolved solids (TDS) was measured by TDS meter, a measuring set was used with specific TDS meter cell and it was calibrated with distilled water at 25°C. The (TDS) of the samples were then determined in ppm. Hach,(2001).

2. pH value:

pH value was measured by pH meter. The pH meter was calibrated by using the standard buffer solutions at 29°C and pH adjusted to (pH = 7) pH value of the samples were recorded. Aranold *et al.,(* 1992).

3. Electric conductivity (EC):

Electric conductivity (EC) was measured by electric conductivity meter. A measuring set was used with specific conductance cell and it was calibrated with (0.01M) KCl the conductivities of the samples were then determined in (µmhos/cm) Aranold *et al.,* (1992).

4. Determination of hardness:

Permanent hardness:

Permanent hardness estimated by evaporating 100 ml of water to dryness on a water bath, with a known volume of 0.1 M sodium carbonate solution. The residue was extracted with freshly boiled hot distilled water and filtered. The insoluble calcium carbonate on the filter paper was thoroughly washed. The filterate (containing the permanent hardness) was cooled and titrated with 0.1 M sodium carbonate solution in the presence of methyl orange indicator.

1 (ml) of 0.1 M (Na_2CO_3) ≡ 0.005 (gm permanent hardness expressed as $CaCO_3$).

Temporary hardness:

Temporary hardness was determined by titrating 100 ml of water sample with 0.1 M HCL using methyl orange as an indicator

1 (ml) of 0.1 M HCl ≡ 0.005 gm of $CaCO_3$

$$2\,HCl + CaCO_3 \longrightarrow CaCl_2 + H_2O + CO_2$$

Or:

$$1\text{ ml of }0.1\text{ M HCl} = \frac{0.05 \times 100(\text{MW } CaCO_3)}{1000\ (\text{for 1 ml})}$$

$$\equiv 0.005\ \text{gm}\ CaCO_3$$

http://books.goole.com/books?

Total hardness:

1 ml of ammonia buffer solution and (3-5 ml) of erichrome black T indicator solution were added to 25 ml of water sample in a volumetric conical flask (250 ml). The solution was then titrated with standard EDTA (0.01 M) till the colour change from wine red to blue.

4. Carbonates and bicarbonates:

To 50 ml of water sample few drops of phenol phthalene indicator solution or methyl orange indicator were added and the sample was titrated with (0.1M) HCl until the color changes from red to blue, Aranold *et. al*., (1992).

5. Calcium ions (Ca^{+2}):

2 ml of NaOH (0.02M) solution and (3–5 ml) of murexide indicator solution was added to 50 ml volume of water sample in a conical flask (250 ml) the solution was then titrated with standard EDTA (0.01 M) solution till the colour changed from purple to wine red.

6. Chloride ions (CL^{-})**:**

To 100 ml of water sample few drops of K_2CrO_4 indicator were added and the solution was titrated against 0.01M $AgNO_3$ till the color changed from yellow to light red.

7. Sulphate ions (SO_4^{-2}):

To 50 ml of water sample, dilute HCl (50%) was added to adjust the pH to 4-5. The solution was heated for few minutes in a water bath. 10 ml of 10% $BaCl_2$ solution were added. The solution was left overnight for precipitation and, then filtered through filter paper. The weight of the residue was determined.

RESULTS AND DISCUSSION

Results of the constituent of the boiler feed water were determined volumetrically and or gravimetrically for each company. They were first tabulated in ml titrant according to the method used and then calculated in ppm for every ion detected.

The Total hardness:

It's the most important test in the experimental work. The total hardness was determined for every company and the average value of the titrant was calculated after carrying three tests for each company, as shown in Table 1.

Table 1: Volume of titrant needed to determine the total hardness for the two companies

Location	**(ml) titrant 0.01 M EDTA**							
	Before Treatment				After Treatment			
	I	II	III	Average	I	II	III	Average
B.N textile	10.50	10.60	10.55	10.55	N.A.			N.A.
Gematex textile	18.20	18.40	18.20	18.27	N.A.			N.A.

N.A: Not Available

It's clear from Table 1 above that although all factories reveal considerable amount of titrant used in the analysis before treatment, yet Gematex factory shows the highest value compared to the Blue Nile textile factory.

Table 2 reveals the average values of the titrant used. It can be used to determine the total hardness in ppm of the two companies.

Table 2: Total hardness as $CaCO_3$ (ppm) for the two companies

Location	**Average (ppm)**		**Standard specified value**
	Before treatment	After treatment	< 10 ppm

B.N. Textile	213	N.A.	
Gematex	364	N.A.	

N.A: Not Available

The total hardness is an expression of the quantity of calcium carbonate that may deposit while boiling and form scales on pipes and other parts of the boiler. This will definitely reflect its effect on the performance and efficiency of the boiler. Figure 1 and Table 2 shows that Gematex Company's value of total hardness is higher than B.N. Textile Company. Nevertheless the values of the two companies deviated from the standard specified value which is less than 10 ppm. (w.w.w.com/boiler water treatment). The values of the total hardness shown in Table 2 reflect the condition of the boiler devices in the two factories.

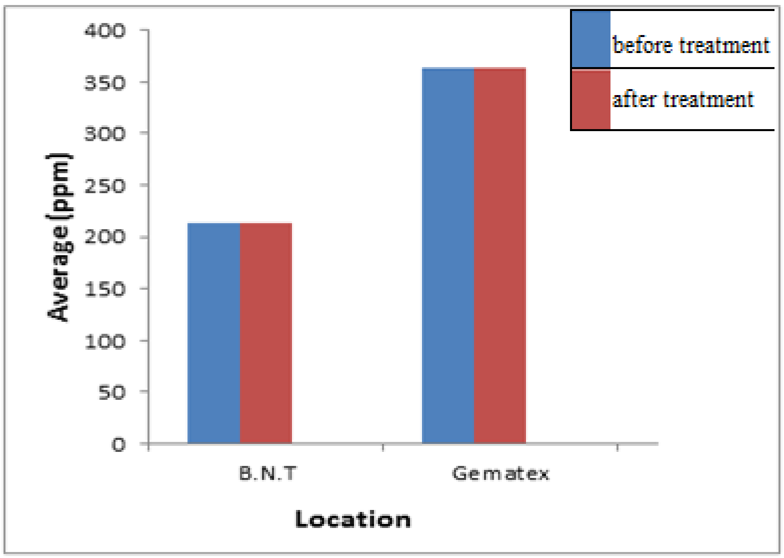

Figure 1: Total hardness as $CaCO_3$ (ppm) for the two companies

The pH values:

The pH values were determined for every company using digital microprocessor. Table 3 below shows the values of pH before and after the treatment of the boiler feed water of the two companies.

Table 3: pH values for the two companies

Location	pH		Standard pH
	Before treatment	After treatment	
B.N. Textile	8.4	N.A.	8.5 – 9.5
Gematex	7.9	N.A.	

N.A: Not Available

As Table 3 shows, the standard specified pH value for boiler feed water is (8.5-9.5) as stated by Bureau of Indian Standard. Gematex Company deviates from the standard by 7.1 % .Blue Nile Textile deviates by 1.2 %. Acidic medium in boiler feed water is corrosive and may cause damage to the parts of the boiler and holes in pipes. This phenomenon was noticed in both Gematex and B.N. Textile factories. The pH values for the two factories are shown in Fig. 2.

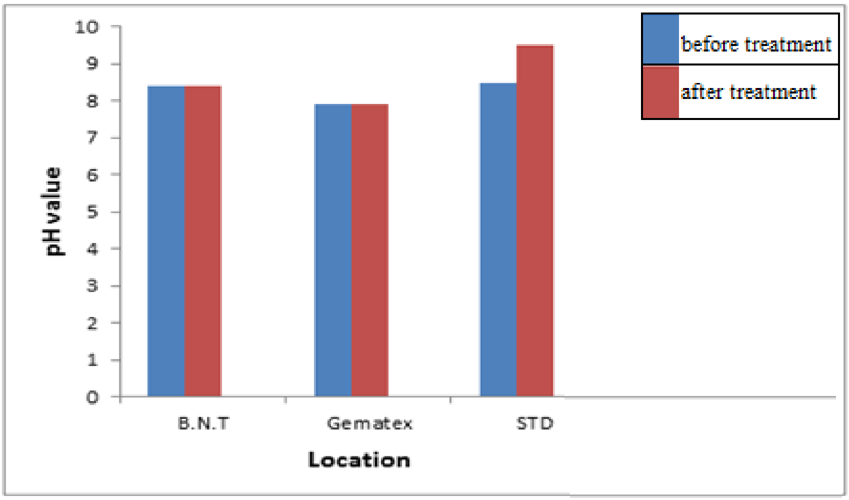

Figure 2: pH values for the two companies

The total dissolved solids:

The total dissolved solids were determined using a micro processing digital device as shown in Table 4.

Table 4: Results of the total dissolved solids for the two companies

Location	**TDS** (mg/L)		**STD**
	Before treatment	After treatment	
B.N. Textile	195	N.A.	4000
Gematex	450	N.A.	

N.A: Not Available

Table 4 reveals that the total dissolved solids in the boiler feed water of Gematex textile factory was higher than that of B.N. Textile factory and it was very high which indicated the reasons for the big decrease of the total dissolved solids values, from 450 to 195 Mg/ L. The specified standard value of total dissolved solids for the boiler feed water as stated by (Degremont, 1991) is 4000 Mg/L. Another reference, (source: www2 spraxsarco com/re :) gives the maximum permissible levels of boiler water TDS in the range of (1500 -10000) ppm which it depending on the type of boiler. Higher levels of TDS in boiler feed water may give rise to foaming.

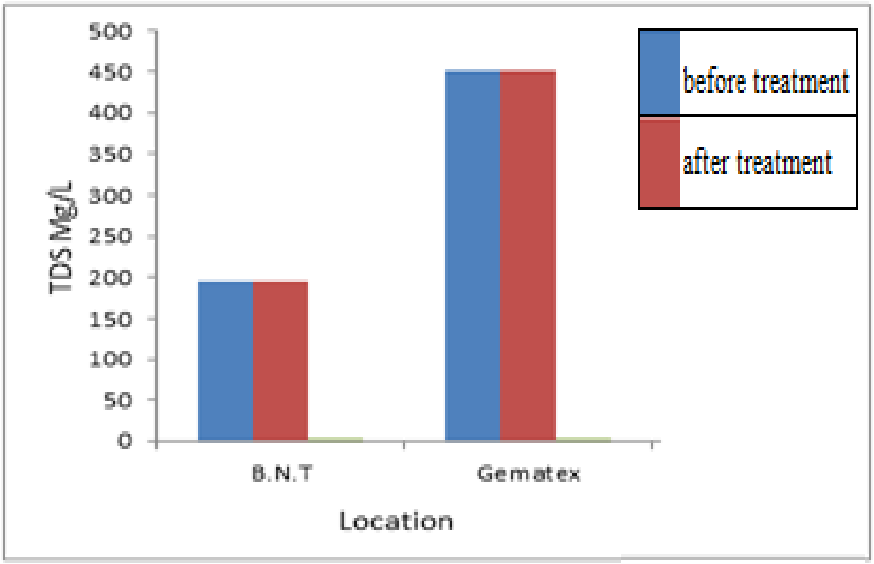

Figure 3: The total dissolved solids for the two companies

The actual dissolved solids concentration at which foaming may start will vary from boiler to boiler. Conventional shell boilers are normally operated with the TDS value in the range of 2000 ppm for larger boilers provided that the boiler operates near its design pressure, and other boiler water conditions are correctly controlled. Below are broad guidelines on the maximum permissible levels of boiler water TDS in certain types of boilers. Table 5 reveals other units used to measure the water constituents. TDS may be expressed in a number of different units. Table 5 gives the approximate conversions from TDS to other units. Degree Bauma and degree Twaddle are alternative hydrometer scales.

Table 5: Comparison of units used to measure TDS and other units

Total dissolved Solids TDS (ppm)	**Conductivity µs/cm**		**Relative density at 15.5 c**	**Degree Bauma °Be**	**Degree Twaddle °Tw**
	Neutral	Un neutral			
0	0	0	1.000	0.000	0.000
200	266	400	1.00036	0.026	0.036
400	571	800	1.00036	0.052	0.073
800	1140.	1600	1.00073	0.105	0.145
1000	1429	2000	1.00091	0.131	0.182
1200	1714	2400	1.00109	0.157	0.218

The Electrical conductivity (E.C.):

The values of the E.C. for the two companies were determined using microprocessor digital device. Table 6 below shows the results.

Table 6: E.C. of the four companies

Location	**E.C.** micro ohm/cm	
	Before treatment	After treatment
B.N. Textile	347	N.A.
Gematex	863	N.A.

N.A: Not Available

As in Table 6 it is clear that the E.C. values of Gematex boiler feed water was higher than that of the Blue Nile Textiles factory.

It is also noticed from Table 6 that the E.C. values of the two companies are far below the typical maximum value of E.C for various boiler types. The highest E.C. value was recorded by Gematex Company being 863 micro ohm/cm which is more than two folds as much of E.C of the B.N. T as shown in Fig. 4.

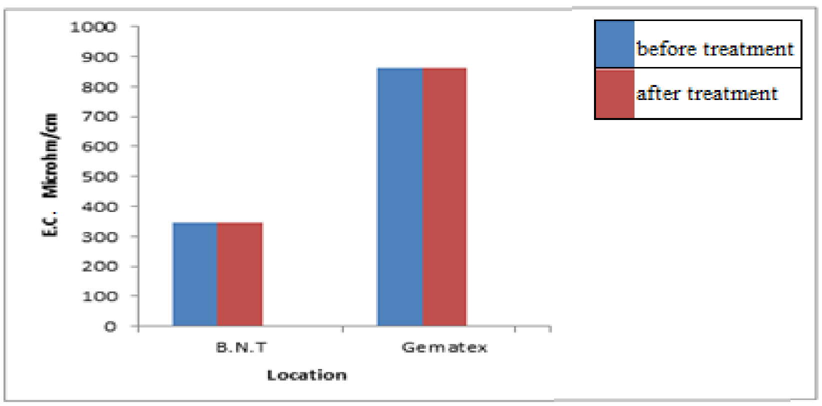

Figure 4: E.C. of the two companies.

The cations and anions in the boiler feed water of the two companies:

Analytical results of different ions in ml titrant:

The Ca^{+2} , Cl^{-} , HCO_3^- , CO_3^{-2} and SO_4^{-2} ions were determined titrimitrically and gravimetrically for the two companies as shown in Table 7 and Table 8.

Table 7: Average volume of titrant needed for titration of some ions in the boiler feed water for Gematex factory.

Gematex		**(ml) titrant**			
Analyte	Titrant	I	II	III	Average
Ca^{+2}	0.01 M EDTA	37.5	37.0	37.0	37.16
Cl^{-}	0.01 M Ag NO_3	8.9	8.5	8.5	8.63
HCO_3^{-} / CO_3^{-2}	0.01 M HCl	36.00	37.20	39.10	37.43
SO_4^{-2}	Ba Cl_2 (10%)	10.10	9.85	10.06	10.00

Table 8: Average volume of titrant needed for titration of some ions in the boiler feed water of Blue Nile Textile Factory.

B.N. Textile		**(ml) titrant**			
Analyte	Titrant	I	II	III	Average
Ca^{+2}	0.01 M EDTA	21.10	21.20	21.20	21.17
Cl^{-}	0.01 M Ag NO_3	1.25	1.30	1.200	1.250
HCO_3^{-} / CO_3^{-2}	0.01 M HCl	10.60	10.41	10.50	10.50
SO_4^{-2}	Ba Cl_2 (10%)	0	0	0	0

The boiler feed water of Gematex shows the highest value of Ca^{+2} ions dissolved in the water, compared with that of the Blue Nile textile factory. CO_3^{-2} and HCO_3^{-} ions were determined simultaneously in one water sample, as it became difficult to determine the CO_3^{-2} ion alone.

As shown in Table 8 the amount of titrant needed to detect the Ca^{+2}ion in the boiler feed water of the Blue Nile textile factory is lower than that of Gematex. Also no SO_4^{-2} was detected in the water.

The different ions of the two companies:

The average values of ml titrant were used to calculate the amount of these ions in ppm. Table 9 underneath shows these results.

Table 9: Some ions in (ppm) of the two companies

Analyte	**B.N. Textile**	**Gematex**	**Standard**
Ca^{+2}	84.40	146.00	≤ 6.0
Cl^{-}	8.700	60.35	—
HCO_3^{-} CO_3^{-2}	46.00	222.00	≤ 4.0
SO_4^{-2}	0.00	83.00	—

Table 9 shows that the values of calcium carbonate and bicarbonate ions in the water samples of Gematex are the highest relative to B.N. textile factory. The total hardness of the water sample of Gematex is also the highest. Both results may be considered as the reason behind boiler deterioration and deficiency in a comparatively short period. B.N. Textile values of these ions are also high and may be one of the reasons for the damage of their boilers

Calcium ion level in Gematex water sample is the highest among all the samples tested. It is higher than B. N. textile by about two times.

The situation of the two boilers in the factories highlighted the importance for more proper and perfect treatment and conditioning of the boiler feed water. The scales, corrosion, damage of boilers parts and low efficiency of the boiler, may all be attributed to the presence of foreign elements like calcium ions found in the water.

Sulphate ions level in Table 9 reveals that it is the high in case of Gematex being 83 ppm while in B.N. Textile it is nil. These ions and the chloride ions are non-scaling. Their role in scaling and corrosion is insignificant as both ions are less-adherent slurry during boiling, and can be removed while the boilers blow down.

CONCLUSION

All water samples of the boiler feed water for the two factories constitute various anions and cations with varying degrees.

Gematex Company shows higher values of total hardness, calcium ions, carbonates and bicarbonate ions in their water samples. The main reason for that is their non-treatment and conditioning of the boiler water. This may be the reason behind the quick deterioration of their boilers. B.N. Textile Company also shows relatively high values in these ions which accumulate inside the boilers forming scales and rendering the boilers inefficient in a short period. It appears from the discussions that the water treatment process which is responsible for the removal of foreign elements from the boiler feed water is of absolute necessity, if the boilers are to run without problems. pH specified standard values should also be maintained to avoid corrosion.

Factories which pay attention to the treatment of their boilers feed water by minimizing the levels of foreign elements, maintaining pH; they secure these boilers from serious limitations.

From the results of the concentration of the anions and cations of the water samples of the two companies, it is that their values are deviated from the standard specified values by different degrees. However, the deviations were specifically in the constituents which affect the scaling and corrosion, and are highest for Gematex Company.

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أثر مكونات الماء على إنتاج مصانع النسيج وكفاءة الغلايات، ولاية الجزيرة، السودان

الملخص

يعد الماء المادة الخام الأساسية للبخار، فالماء يحتوي على أنواع مختلفة من الشوائب. المياه النقية تماما هي المرغوبة لأنظمة توليد البخار. الغلاية هي وعاء مغلق تتم فيه تحويل الماء تحت الضغط إلى بخار عن طريق استخدام التسخين. عندما يتم غلي الماء إلي البخار يزداد حجمه حوالي 1600 مرة مما ينتج قوة تكاد تكون متفجرة مثل البارود. هذا يؤدي إلى أن تكون الغلاية معدات خطيرة للغاية يجب استخدامها بعناية فائقة. تناولت هذه الورقة دراسة أثر مكونات الماء على كفاءة الغلايات وإنتاج مصانع النسيج. تم جمع عينات من المياه من موقعين مختلفين بشكل رئيسي من شركة النيل الأزرق للنسيج وشركة جيماتكس للمنسوجات بولاية الجزيرة بالسودان. للتحليل الكيميائي ، مثل: المواد الصلبة الذائبة الكلية (TDS) ، قيمة الرقم الهيدروجيني، التوصيل الكهربائي (E.C) ، الكربونات (CO_3^{-2}) وبيكربونات (HCO_3^{-1}) ، أيون الكالسيوم (Ca^{+2}) والصلابة المؤقتة. أظهرت النتائج التي تم الحصول عليها أن عينات من مياه تغذية الغلاية للمصنعين تحتوي العديد من الأنيونات والكاتيونات بدرجات متفاوتة .يجب اعتماد جميع العمليات الموصى بها في خط الأنابيب لتكييف مياه تغذية الغلايات والحفاظ عليها بشكل مثالي قبل دخول الماء إلى الغلاية لتجنب المشكلات الخطرة.