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Advanced Non Chemical Water Treatment Process for TDS Reduction in Cooling Tower – Specific Study on Calcium, Magnesium & Sulphates

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Abstract

The primary objective of this research is to **study the concentration levels of Calcium, Magnesium & Sulphates** during the non chemical water treatment process **(in specific to hydro dynamic cavitation principles)** in the cooling tower

The study is aimed at making the cooling tower water qualitatively reusable for multiple cycles.

Introduction:

Ground water is the only source for major industries located in the urban sector. Thus it is important that the ground water is optimally used and reused effectively.

The circulating water entering the cooling tower under goes various changes in its state and chemical composition due to addition of various elements and minerals during the flow. The TDS content typically increases above the normal range of 500mg/dl during the cooling tower circulation process, which needs to be recovered.

The hydrodynamic cavitation principle studied in this paper is effective in reducing the calcium, magnesium and Sulphate levels which form the major components in evaluating the TDS content.

The Hydro Dynamic Cavitation (HDC) technology causes the circulating water under go high temperature and high velocities by which the dissolved solids like calcium magnesium and sulphur tend to form precipitates which is later filtered through a separate unit.

Today's Industries are in scarcity of water resources and it is necessary for every industry to look for cost effective and efficient water treatment systems. In view to address this challenge for the industrial needs, the cost effective method of cracking the dissolved salts by natural mechanical means is one of the efficient identifiable solution.

Keywords: Non-Chemical water treatment, Air Compressor, tangential flow in the nozzle, different flow rates, cavitation chamber, Nozzle diameter, Total Dissolved Solids (TDS),Hardness of water($CaCo_3$)., Calcium / Magnesium & Sulphates.

INTRODUCTION TO HDC PRINCIPLE

THE COOLING TOWER :

The Overview:

The cooling tower is a mechanical device used to remove heat from circulating water which runs through various machinery and industrial system. The cooling towers are prominently used in power plants, refineries , food processing plants, petro chemical plants, semi conductor plants and other industrial facilities.

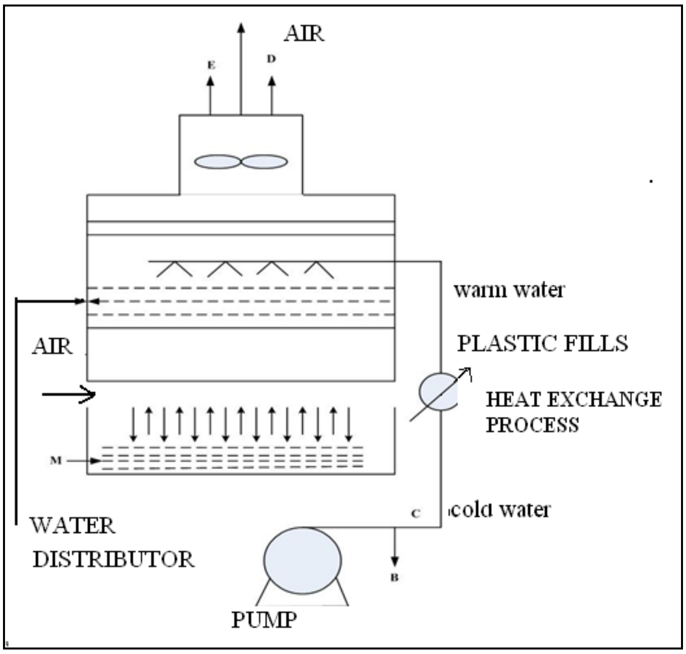

Figure 1: Cooling Tower

Hydrodynamic Cavitation principle:

For enhancing precipitation formation, HDC appears to be most suitable for non chemical method of removing precipitates from the cooling tower water[1].

As illustrated fig below, the HDC technology system is tangential treatment. It includes two parts:A nozzle system and filtration tank.

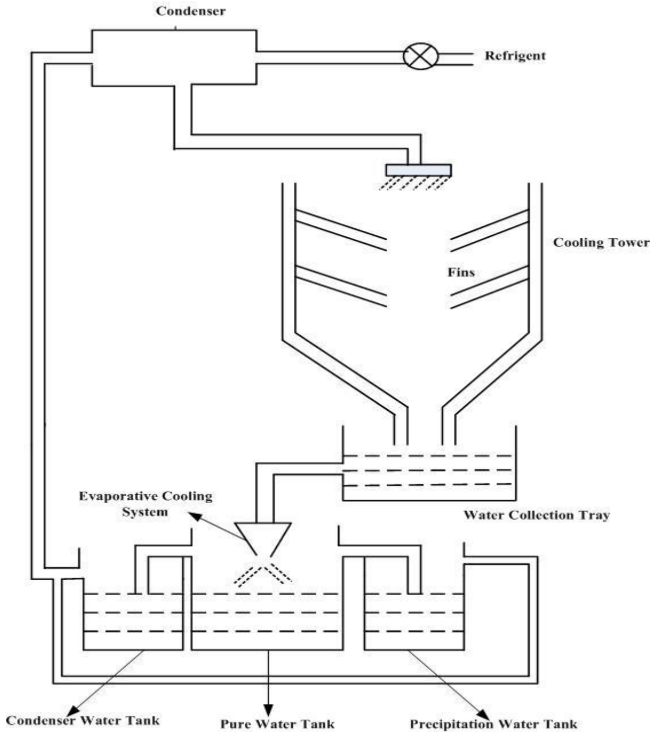

Figure 2: Schematic Diagram Of a Modern Cooling Tower With HDC Mechanism

The filtration system is used to dig out the precipitated calcium carbonate and other suspended solids from the circulating cooling water.

The system works on the principle of Hydrodynamic Cavitation(HDC). These hydrodynamic cavitation is referred by Evaluation of Non Chemical Treatment Technologies for Cooling Towers at Select California Facilities.et al. (February 2009).

In turbulent liquids, and at high velocity, hydrodynamic cavitation will occur. Cavitation is the dynamic process in a fluid where micro-sized bubbles form, grow, and collapse[3]. When pressure decreases to a low values, cavities are formed in the liquid[4]. When pressure increases, the cavities cannot sustain the surrounding pressure, and consequently, collapse creating localized points of extreme high pressure and temperature. As the bubble collapses, the pressure and temperature of the vapour within it increases. The bubble will eventually collapse to a minute fraction of its original size, at which point the gas within dissipates into the surrounding liquid via a rather violent mechanism, which releases a significant amount of energy in the form of an acoustic shock-wave and as visible light. At the point of total collapse, the temperature of the vapour within the bubble may be several thousand Kelvin, and the pressure several hundred atmospheres. Resulting in the chemical reaction settling in and will release co_2 and other dissolved gases from the solution. By this technology we can allow the formation of precipitation of calcium carbonate, and other micro organisms.

Mechanism OF tangential flow of HDC :

1. Water from the sump is pumped under pressure into the cavitation chamber, where it is forced to rotate at high velocity through nozzles.

2. The opposing water streams collide in the cavitation zone, causing millions of high energy, micro-sized cavitation bubbles to rapidly form and collapse. This stresses the bacteria and forces calcium carbonate to form a precipitate in the water.

3. The treated water exiting the cavitation chamber is returned to sump where the precipitated calcium carbonate is removed by the filtration system.

Design Parameters of Nozzle

Table 1. Nozzle Parameters

inlet of nozzle Diameter	75mm
Water Inlet Diameter	30mm
Length of Nozzle	75mm
Out Nozzle Diameters	16,14,12mm
Cover Plate Diameter	75mm
Height of the cover plate	20mm
Water entry from Tangential hole of nozzle diameter	8mm
Air entry from cover plate nozzle	6mm

Design parameters of filtering tank& cavitation chamber:

Table 2

Length	130cm
Width	130cm
Height	130cm
Cavitation chamber	200,300,400mm

Figure 3. Vortex Mechanisms in cavitation chamber

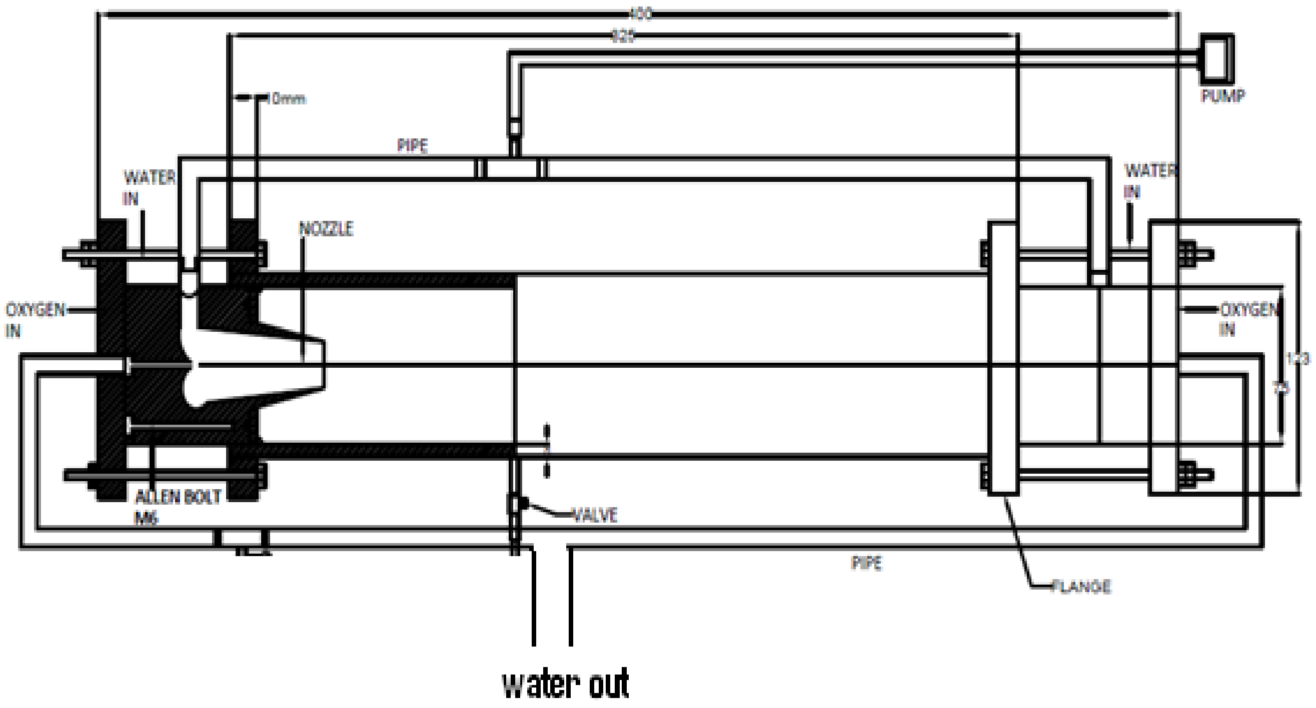

Figure 4: layout of tangential flow Nozzle

MODEL OF A NOZZLE:

Initially in experimental work, a tangential opposite holes of a nozzle is designed.

Nozzle designs are shown in the figs.

Assembly Of HDC With Filtration Tank:

The equipment consist of two nozzles and these set up is immersed in a tank so that the water can be re-circulated in the tank.1HP motor is connected to circulate water from tank to nozzles, and all pipe fittings are made properly, A flow meters connected to the nozzles and fitted properly to the tank. An air compressor at a capacity of 8bar is attached to the nozzles , and the flow can be regulated through the a values.

Figure 5. Nozzles with Top Plate

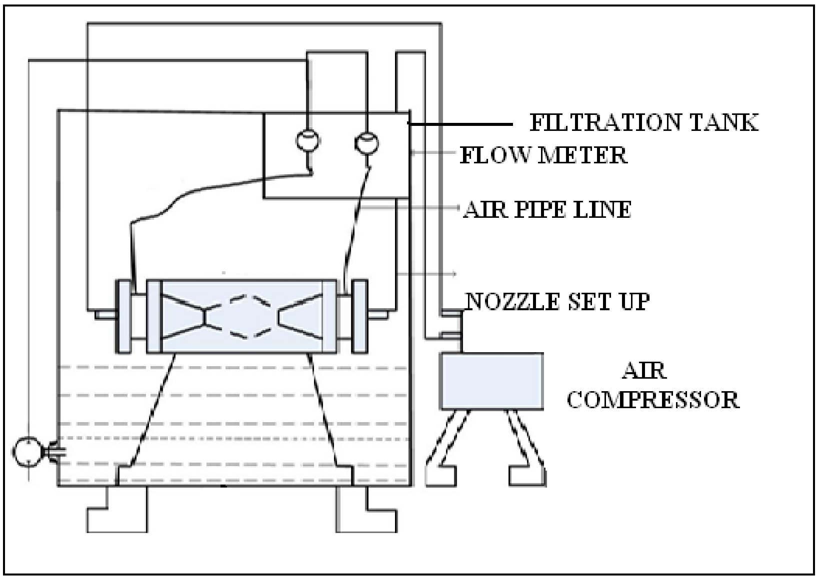

Figure 6: Assembly Of HDF With Filtration Tank

EXPERIMENTS

Ground water sample is collected, and water analysis has done as per IS: 10500:2012.so, the results obtained are

Experiments

Experiment conducted Water at Pressure 1 bar, cavitation chamber of length 300mm.

At Air Pressure 1 bar the cavitation chamber of length 300mm, water Circulating 30 min through a nozzle of 16 mm diameter.

Now collect water sample after 30, 60, 90, 120, 150 minutes, Calcium, Magnesium, sodium, potassium, chloride & sulphate results obtained for water analysis as mentioned in a table below.

Table 3: Ground water sample results

SI.NO.	Characteristic	Test method	Results	Acceptable Limit
1	Total Dissolved Solids, mg/l	IS:3025(pt-16)	946	< 500
2	Total Hardness as $caco_{3,}$mg/l	IS:3025(pt-21)	528	< 200
3	Calcium as ca ,mg/l	IS:3025(pt-40)	121.6	< 75
4	Magnesium as Mg ,mg/l	IS:3025(pt-46)	53.8	< 30
5	pH value	IS:3025(pt-11)	7.10	6.50-8.50

Table 4: water analysis results at a pressure 1 bar

S.no	characteristic	Raw Water characteristics	Settling time 30(min)	Settling time 30(min)	Settling time 30(min)	Settling time 30(min)	Settling time 30(min)
1	Calcium as ca ,mg/l	121	102.4	99.2	96.8	92.8	101.6
2	Magnesium as Mg ,mg/l	53.8	44.2	42.2	41.8	40.3	42.7
3	Sodium as Na, mg/l	77.3	63	70.4	69	150.7	69
4	Potassium as K, mg/l	7.0	07	6.2	6.0	5.5	5.5
5	Chloride as Cl, mg/l	142	142	142	142	142	142
6	Sulphate as SO_4 ,mg/l	149.8	141.1	150.7	111.4	150.7	155.5

Experiment conducted Water at Pressure 1.5 bar, cavitation chamber of length 300mm.

At Air Pressure 1.5 bar the cavitation chamber of length 300mm ,water Circulating 30 min through a nozzle of 16 mm diameter.

Now collect water sample after 30, 60, 90, 120, 150 minutes, Calcium, Magnesium, sodium, potassium, chloride & sulphate results obtained for water analysis as mentioned in a table below.

Table 5: water analysis results at a pressure 1.5bar

s.no	Characteristics	Raw Water characteristics	Settling time 30(min)	Settling time 30(min)	Settling time 30(min)	Settling time 30(min)	Settling time 30(min)
1	Calcium as ca ,mg/l	121	102.4	98.4	97.6	93.6	96
2	Magnesium as Mg ,mg/l	53.8	44.2	42.7	42.2	39.8	40.3
3	Sodium as Na, mg/l	77.3	54.7	68.5	67.6	69	77.3
4	Potassium as K, mg/l	7.0	6.0	6.2	6.2	6.2	5.5
5	Chloride as Cl, mg/l	142	163.3	142	142	149.1	142
6	Sulphate as SO_4 ,mg/l	149.8	104.6	145	145	124.8	169

3.1.3. Experiment conducted Water at Pressure 2 bar, cavitation chamber of length 300mm.

At Air Pressure 2 bar the cavitation chamber of length 300mm ,water Circulating 30 min through a nozzle of 16 mm diameter.

Now collect water sample after 30, 60, 90, 120, 150 minutes, Calcium, Magnesium, sodium, potassium, chloride & sulphate results obtained for water analysis as mentioned in a table below.

Table 6: Water analysis results at a pressure 2 bar

s.no	characteristic	Raw Water characteristics	Settling time 30(min)	Settling time 30(min)	Settling time 30(min)	Settling time 30(min)	Settling time 30(min)
1	Calcium as ca ,mg/l	121	100.8	97.6	96	96	93.6
2	Magnesium as Mg ,mg/l	53.8	43.2	41.3	41.3	40.3	39.8
3	Sodium as Na, mg/l	77.3	52.9	57	62.1	67.2	67.2
4	Potassium as K, mg/l	7.0	6.2	6.2	6.2	6.2	6.2
5	Chloride as Cl, mg/l	142	142	142	156.2	163.3	163.3
6	Sulphate as SO_4 ,mg/l	149.8	131.5	134.4	121.9	99.8	101.8

FIGURES OF VARIOUS FINDINGS:

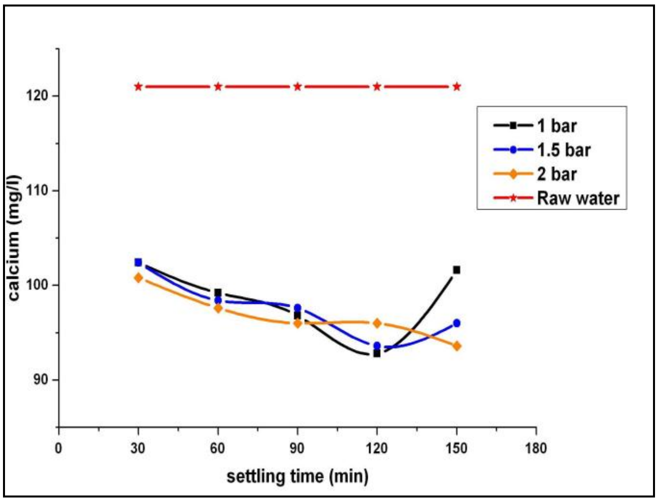

Figure 7: Variation of calcium at various settling times

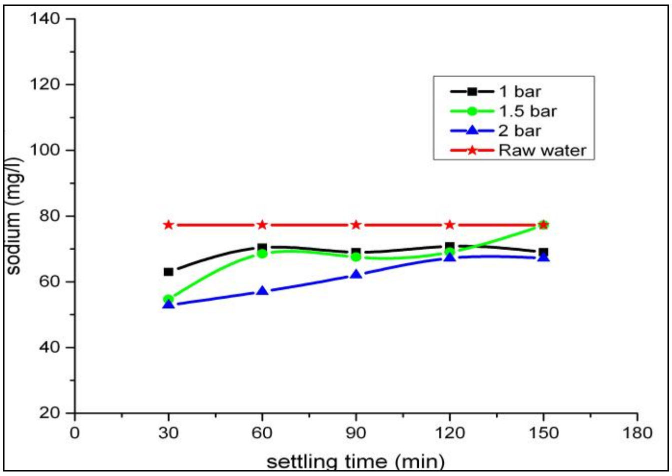

Figure 8: Variation of sodium at various Settling times

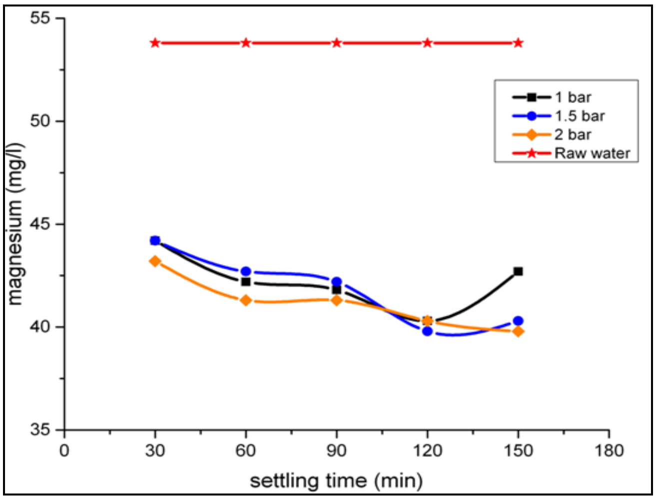

Figure 9: Variation of magnesium at various settling times

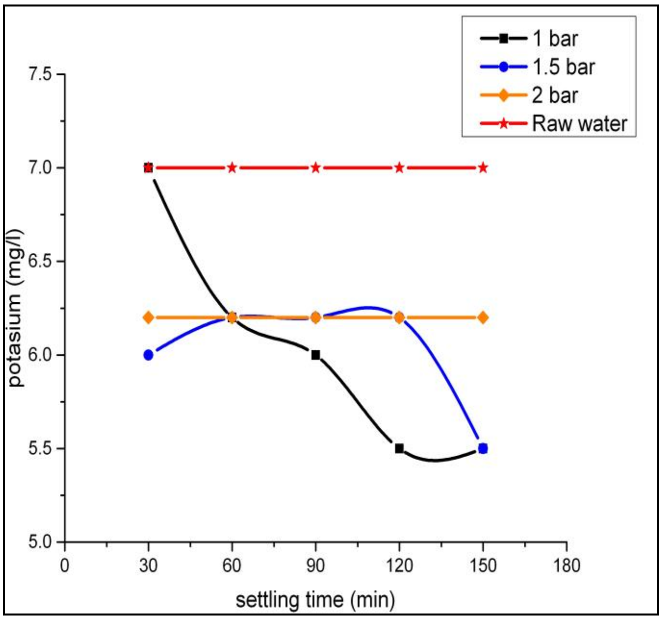

Figure 10: Variation of potassium at various settling time

RESULTS & DISCUSSIOUS

- Form fig 7 it is clear that calcium present in treated water will be reducing with air supply under pressure and increasing settling time, up 120 minutes.
- Form fig 8 it is observed that sodium present in treated water will be reducing with air supply under pressure and increasing settling time, up 90 minutes.
- Form fig 9 it is studied that magnesium present in treated water will be reducing with air supply under pressure and increasing settling time, up 120 minutes.
- Form fig 10 it is clear that potassium present in treated water will be reducing with air supply under pressure and increasing settling time, up 90 minutes.
- However, for easy handling the optimum settling time for commercial operation is observed after detailed experimentation varying between 60 to 90 minutes.

REFERENCES

[1] V.V. Ranade and V.M Bhandari, industrial waste water treatment Recyecle & Reuse Elsevier, Amsterdam(2014),

[2] P.R. Gogate, J.Environ.manage., 85,80,(2007)

[3] S.S.Sawant,A.C.anil,V.Krishnamurthy,C.Gaonkar,J. Kolwalkaar,L.Khandeparker,D.Desai,A.V.mahulkar, V.V.Ranade and A.B pandit, Biochem. Eng J.,42, 320(2007).

[4] A.A. Kulkarni,V.V. Ranade ,R. Rajeer and S.B Koganti, AICHE J.,54,1139(2008).

[5] Ortega-Casanova ,N. campos R. Fernandez-Feria "*Swirling jet models based on experimental measurements at the exit of swirl vane nozzles"* Submitted to the Journal of Hydraulic Research

[6] Escudier, M. P., Bornstein, J., & Zehnder, N. 1980. "*Observations and LDA measurements of confined turbulent vortex flow*". J. Fluid Mech., 98:49–63, 1980.

[7] Gallaire, F., Rott, S., & Chomaz, J. M "*Experimental study of a free and forced swirling jet*".Phys. Fluids, 16:2907–2917, 2004.

[8] Garg, A. K., & Leibovich, S. "*Spectral characterization of vortex breakdown flowfields"*. Phys.Fluids, 22:2053–2064, 1979.

[9] Hall, M. "*Vortex breakdown"*. Ann. Rev. Fluid Mech., 4:195–218, 1972.

[10] Harvey, J. K. 1962. "*Some observations of the vortex breakdown phenomenon*". J. Fluid Mech.,14:585–592, 1962.

[11] Leibovich, S. "*The structure of vortex breakdown"*. Ann. Rev. Fluid Mech., 10:221–346, 1978. Leibovich, S. "*Vortex stability and breakdown: Survey and extension*". AIAA J., 22:1192-1206,1984