International Journal of Engineering Studies.
ISSN 0975-6469 Volume 8, Number 2 (2016), pp. 259-275

http://www.ripublication.com

Reducing of a Scalling in a Cooling Tower by Areation Process

K. Naveena Latha
Assoc.professor, Department of Mechanical Engineering,
TKR College of Engineering & Technology, Hyderabad, India.
E-mail: naveenalatha.k@gmail.com

Dr. P. Ram Reddy
Professor, Department of Mechanical Engineering,
Former Registrar, JNTUH, Hyderabad, India.
E-mail: ramreddy1944@gmail.com

Dr. D.V. Ravi Shankar
Professor, Department of Mechanical Engineering,
TKR College of Engineering & Technology, Hyderabad, India.
E-mail: shankardasari@rediffmail.com

P. Venkateshwar Reddy
Asst.Professor, Department of Mechanical Engineering,
TKR College of Engineering & Technology, Hyderabad, India.
E-mail: mr.pvreddy@gmail.com

Abstract

Industrial waste water treatment is the process of removing pollutants from water using a combination of chemical, biological and physical methods. This paper describes an alternative method for controlling the total dissolved solids, Hardness, scaling and bacteria growth in a cooling tower by "aeration method"

Many water treatment technologies have been in use since long. Out of these a new technology cavitation has proved to be useful on large scale operations in industry. Cavitation is a physical phenomenon associated with three aspects: formation, growth and collapse of vapor or gas-vapor bubbles within the body of a liquid due to variations of local static pressure. Decreasing the pressure over a liquid and bringing it to its vapor pressure at the operating temperature generates vapor bubbles in the liquid. When the pressure is brought back to normal pressure, these vaporous bubbles collapse with a bang to generate intense pressure and temperature at the point of collapse. Such intense conditions (5,000atm and 12,000°K, intense turbulence) and resulting shock wave can bring about several physical, chemical & biological transformations, even when the bulk conditions are ambient.

In this present study, the scaling is the important aspect, so in a cooling tower continuous circulating of water, evaporates and which leads to increases in the dissolved salts concentration. So, these salts can be reduced by aeration method, which reduces the carbon dioxide, oxidation of iron and manganese, ammonia and hydrogen sulfide reduction.

In the present study, reducing of Hardness and TDS is the major factor, because the problem of choking fills in a cooling tower requires frequent replacements. The cost of filling materials is 30% of the total cost of the cooling tower. The maintaince cost is the major problem in industry.

Keywords: Air Compressor, tangential flow in the nozzle, different flow rates, Total Dissolved Solids (TDS), Hardness of water ($caco_3$).

INTRODUCTION

Industrial cooling towers can be used to remove heat from various sources such as machinery or heated process material. The primary use of large, industrial cooling towers is to remove the heat absorbed in the circulating cooling water systems used in power plants, petroleum refineries, petrochemical plants, natural gas processing plants, food processing plants, semi-conductor plants, and other industrial facilities.
In the cooling tower, hot water is sprayed downward direction, and air is blown upward with the use of a fan. As the hot water contact the air, some of the water droplets evaporate, and the air absorbs the heat released from this evaporation there by lower the temperature of the remaining water. An outside source of water, commonly referred to as “makeup water,” adds more water to the system to make up for evaporation and other water losses. Then the water is re circulated back to the heat exchanging equipment and the process is repeated [1].
As water is re circulated, minerals such as calcium carbonate (CaCO3), iron and silica become concentrated. Calcium carbonate exists in the form of calcium (Ca+) and bicarbonate (HCO3) ions in water. As the water temperature increases, the calcium ion precipitates insoluble in water with increasing temperature. When the calcium ion precipitates, it forms an adherent deposit (scale). This scale forms on heat exchanger surface. the diffusion of calcium ions is accelerated by the relatively higher temperatures around the heat exchanger surface[2].The heat exchanger transfers heat less efficiently as the scale builds up. This buildup also blocks water flow in the lines.

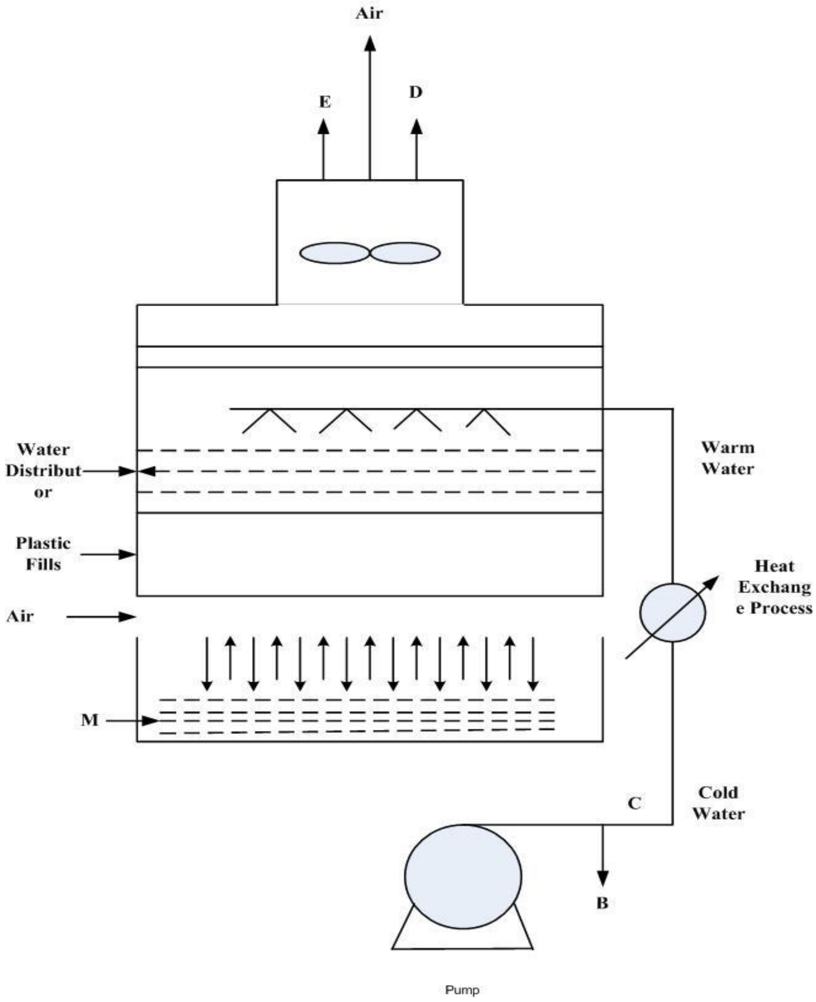

Fig 1. Cooling Tower

1.1 working principle of cavitation technology:

These mechanism is most applicable for Non-chemical treatment of water, removing precipitation formed in cooling tower[3].

The mechanism works on the principle of Controlled Hydrodynamic Cavitation. Cavitation is the dynamic process in a fluid where micro-sized bubbles are form, grow, and collapse [4]. When pressure falls below a critical value of pressure, cavities are formed in the liquid [5]. 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 vapor 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.

This unit consists of mainly two parts: 1.tangential set of nozzles 2.filtration tank.

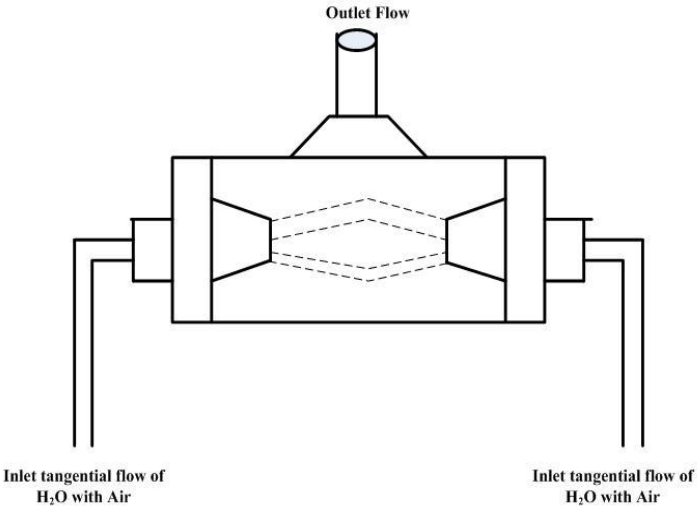

Fig 2. Schematic Diagram of Tangential Flow cavitation Mechanism

1.2. Formation of calcium carbonate without chemicals

The hard water contains a large amount of calcium in the form of relatively soluble calcium hydrogen carbonate $Ca(HCO_3)^2$, therefore in water calcium carbonate Ca2+ and bicarbonate HCO_3^- ions are present. When external energy is supplied,the carbon dioxide CO_2 (g) evolves and raise the solid calcium carbonate $CaCO_3$(s):

$$Ca^{2+} (aq) + 2(HCO^-_3)(aq) \rightleftarrows CaCO_3(S) + CO_2(aq) + H_2O(l) \rightarrow CaCO_3(s) + CO_2(g) + H_2O(l)$$

The resulting calcium carbonate $CaCO_3$ (Calcite polymorph) is heat-insulating and is therefore is effected for the heat transfer in a heating element. The above reaction is actually a compilation of two equilibrium reactions.

Reaction 1: the carbonate-bicarbonate equilibrium

HCO_3^- ions react with itself (HCO_3^- is amphoteric) according to the following chemical equilibrium:

$$HCO_3^- + HCO_3^- \rightleftarrows H_2CO_3 + CO_3^{2-}$$

The formed H_2CO_3 is unstable and breaks down into CO_2 carbon dioxide and H_2O water. By heating the water, the solubility of carbon dioxide in the water decreases and disappears from the water. The above chemical equilibrium CO_2 disappears, and ensures that new CO_2 is formed: the chemical equilibrium shifts to the right (according to the principle of Le Chatelier). Because by replenishing CO_2 there is also CO_3^2- formed, which does not disappear from the reaction, the concentration of CO_3^{2-} ions is increased.

Reaction 2: The solubility equilibrium of calcium carbonate

The presence of Ca^{2+} ions will react with the now largely present, of CO_3^{2-} ions to calcium carbonate (lime scale):

$$\mathbf{Ca^{2+}(aq) + CO_3^{2-}(aq) \rightarrow CaCO_3(s)}$$

Since calcium carbonate is insoluble in water, this equilibrium moves strongly to the right.

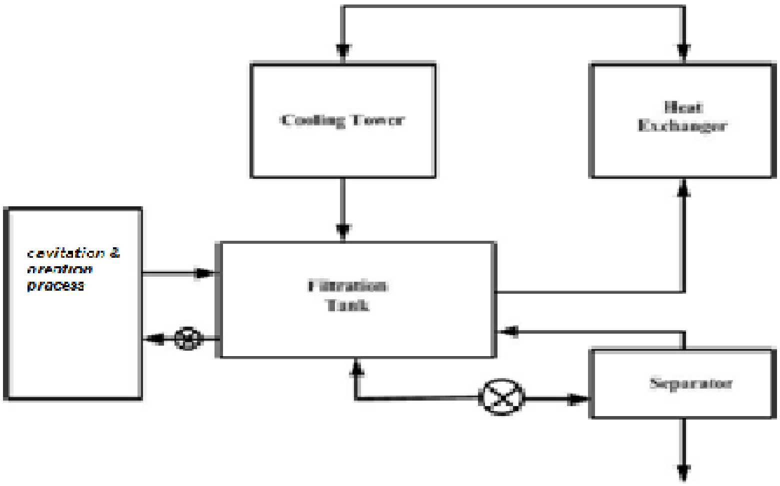

Fig 3. Schematic Diagram of a Modern Cooling Tower with aeration Mechanism

2.0 METHODOLOGY

The design parameters of the tangential nozzle/filtration tank is given below

2.1. Design specification of tangential nozzles and filtration tank:

S.NO	Parameters	dimensions
1	Inlet nozzle Diameter	75mm
2	Water Inlet Diameter	30mm
3	Nozzle length	75mm
4	Nozzle out let Diameter	12mm
5	Cover Plate Diameter	75mm
6	Thickness of the cover plate	20mm

2.1.2. Design parameters of filtering tank:

1	Length	130 cm
2	Width	130 cm
3	Height	130 cm

3. MODELLING OF A NOZZLE

Initially in experimental work, a tangential opposite holes of a nozzle is designed. Nozzle designs are shown in the figs

Fig 4. Nozzle with Top Plate

3.1. Assembly of Aeration Mechanism 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.

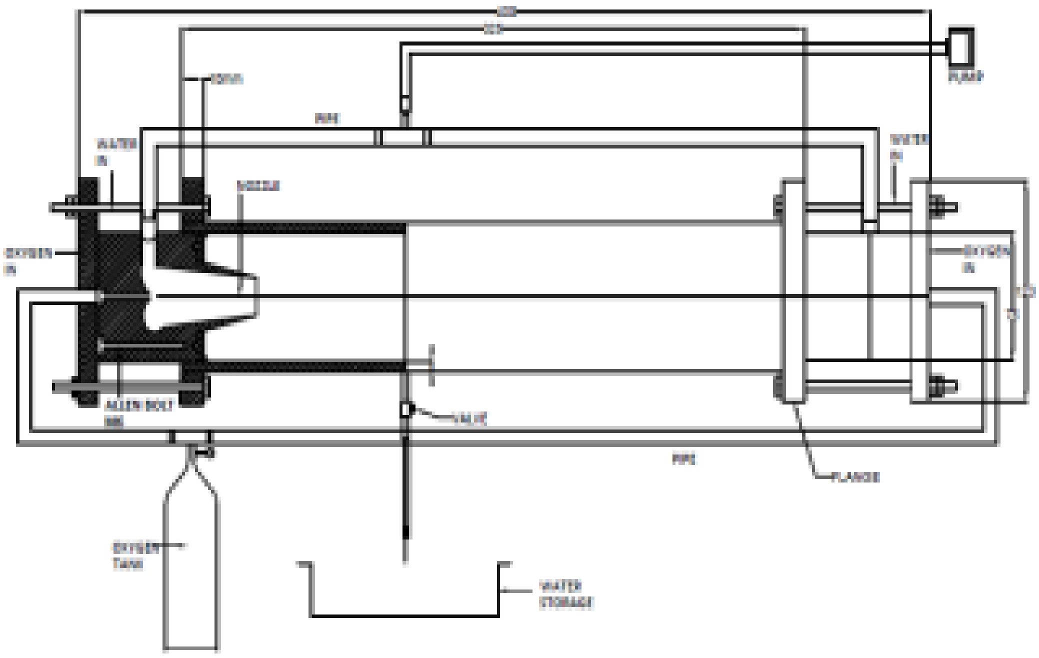

Fig 5. Layout Diagram of Tangential Flow Nozzle

Fig 6. HDVPM Assembly Layout

4. RESULTS AND DISCUSSION

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

Table 1. Ground Water Analysis

SI.NO.	Characteristic	Test method	results	Acceptable Limt
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	P^H value	IS:3025(pt-11)	7.10	6.50-8.50

4.1. Experiment of Water at Pressure 1 bar (sample water collected at every 10 min)

At air pressure 1 bar ,water circulating through a tangential nozzles is 30min and flow rate of nozzles at initial readings are Q1= 69 kilo/litres Q2=74 kilo/litres

Now collect water samples for every 10, 20,30,40,50 Mins ,the results obtained for water analysis are,

Table 2: Analysis of Water at 1 bar

S.No.	Settling Time, Min	TDS, mg/l	Hardness $Caco_3$	P^H
1	10	810	320	7.41
2	20	802	312	7.37
3	30	804	304	7.38
4	40	808	310	7.28
5	50	804	320	7.29

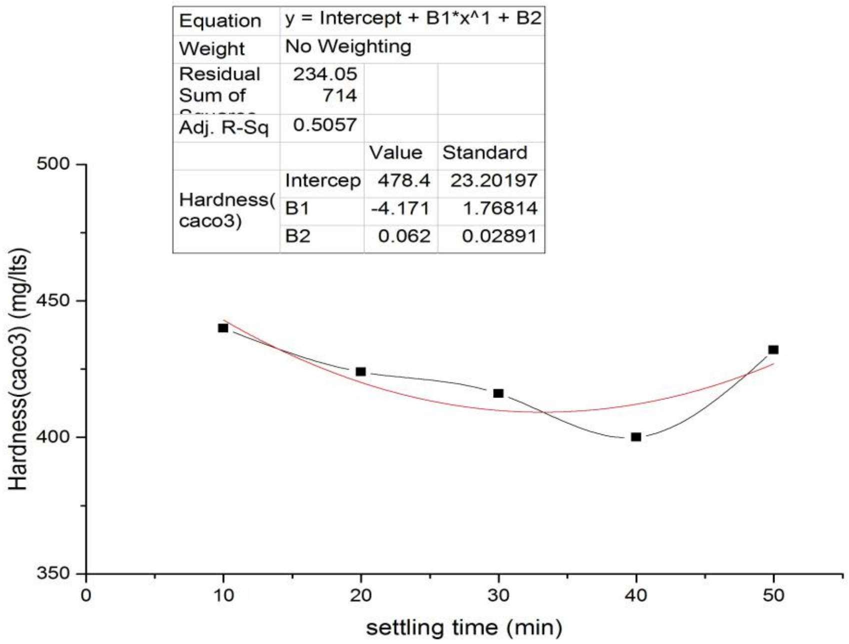

Fig 9. Effect of hardness mg/litres

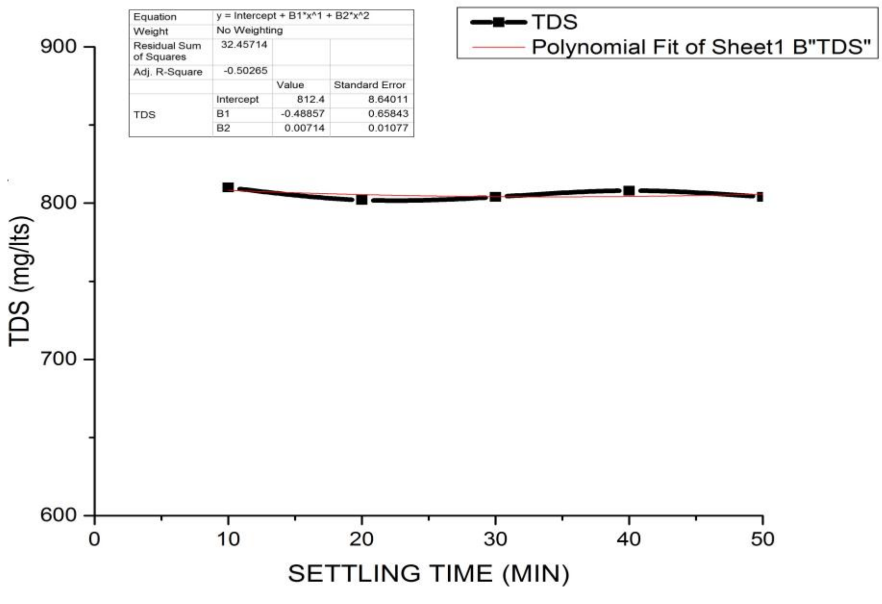

Fig 10. Effect of TDS mg/litres

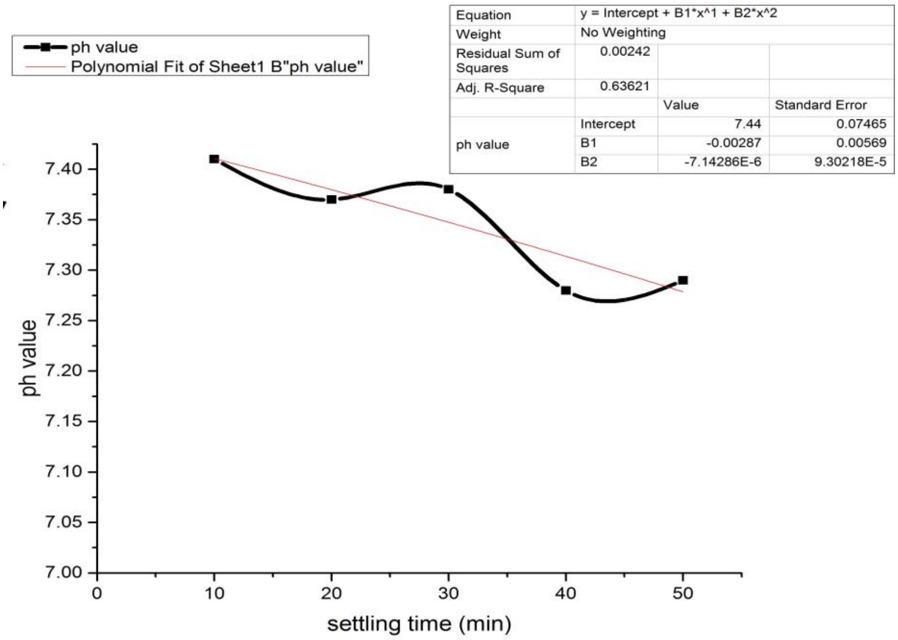

Figure 11. Effect of P^H values

The results of Hardness, TDS, and P^H obtained are shown in Table 3, Here in this study we observed that the values of Hardness, and P^H decreasing up to sometime but TDS value increases, but these value will be less when compare to ground water. And again it will increases if the settling time increases.(i.e., for 50 mins).

4.2. Experiment of Water at Pressure 3 bar (sample water collected at every 10 min)

Table 3: Analysis of Water at 3bar

S.No.	Settling Time, Min	TDS, mg/l	Hardness $Caco_3$	P^H
1	10	784	408	7.36
2	20	780	400	7.32
3	30	820	376	7.94
4	40	788	384	7.38
5	50	768	296	7.35

At air pressure 3 bar ,water circulating through a tangential nozzles is 30min and flow rate of nozzles at initial readings are Q1=29 kilo/litre Q2=34 kilo/litre
Now collect water samples for every 10, 20,30,40,50 Mins ,the results obtained for water analysis are,

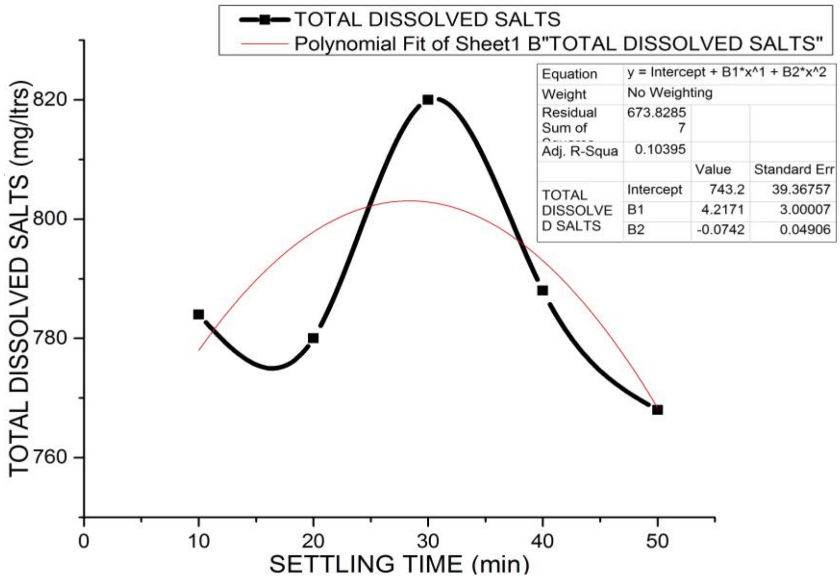

Fig 12. Effect of TDS mg/Litre

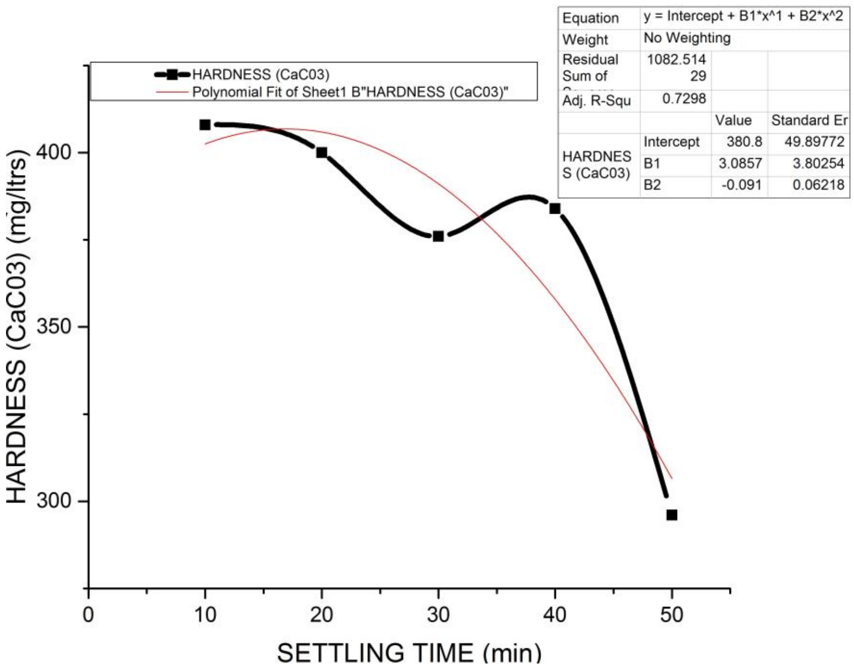

Fig 13. Effect of Hardness mg/litr

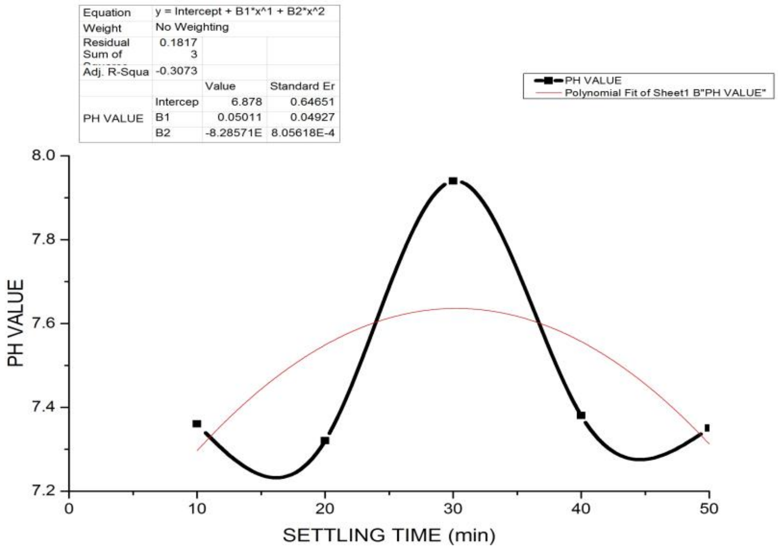

Figure 14. Effect of P^H values

The results of Hardness, TDS, and P^H obtained are shown in Table 3, Here in this study we observed that the values of TDS, and P^H decreasing up to sometime but Hardness value increases, but these value will be less when compare to ground water. And again it will decreases if the settling time increases. (i.e., for 50 mins).

4.3. Experiment of Water at Pressure 5bar (sample water collected at every 10 min)

At air pressure5 bar, water circulating through a tangential nozzles is 30min and flow rate of nozzles at initial readings are Q1=23 kilo/litre Q2=27 kilo/litre

Now collect water samples for every 10, 20,30,40,50 Mins, the results obtained for water analysis are,

Table 4: Analysis of Water at 5 bar

S.No.	Settling Time, Min	TDS, mg/l	Hardness $Caco_3$	P^H
1	10	758	392	7.32
2	20	756	424	7.36
3	30	758	408	7.39
4	40	770	432	7.42
5	50	766	390	7.35

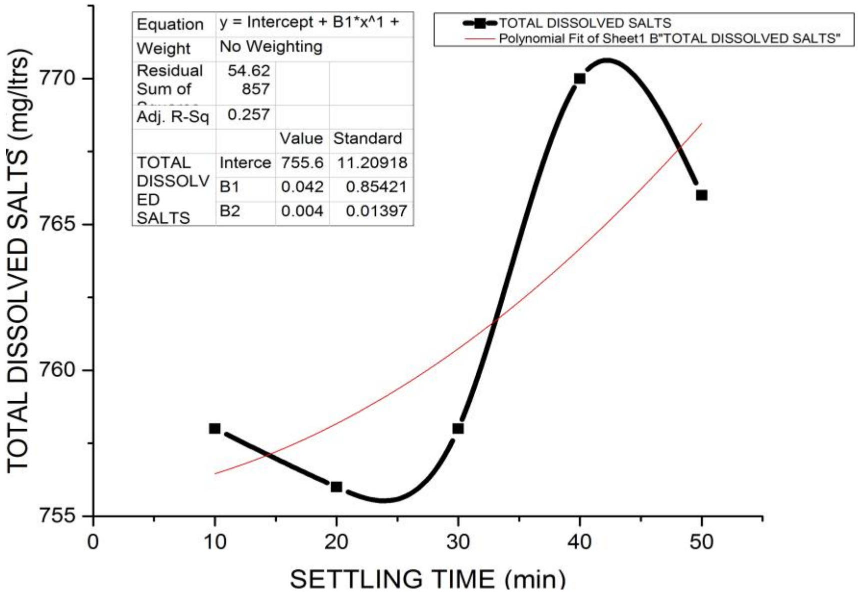

Fig 15. Effect of TDS mg/litre

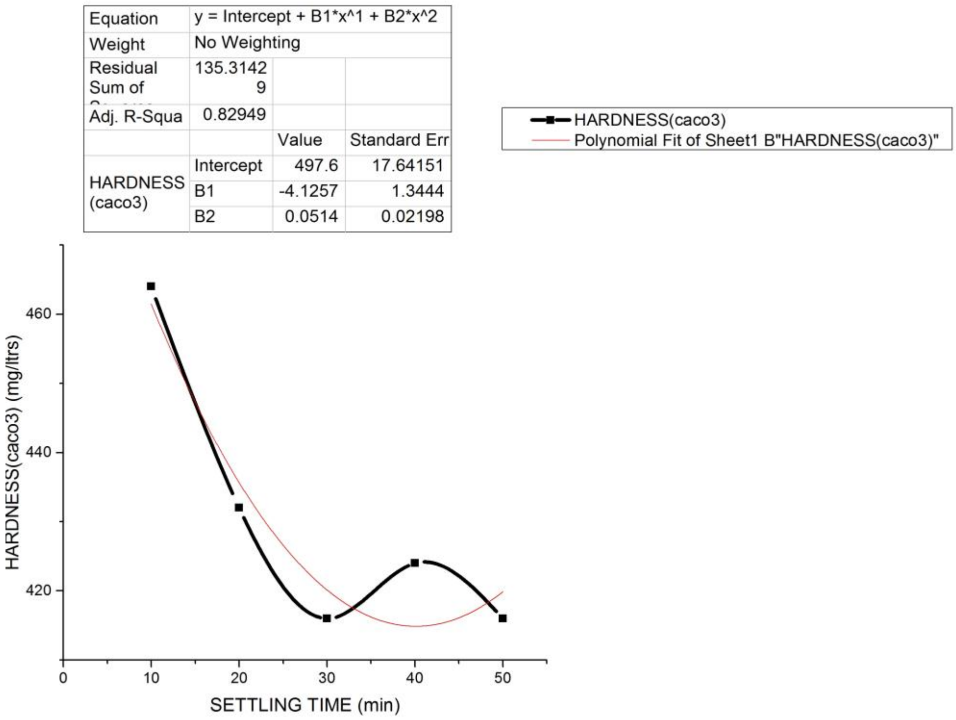

Fig 16. Effect of Hardness mg/litre

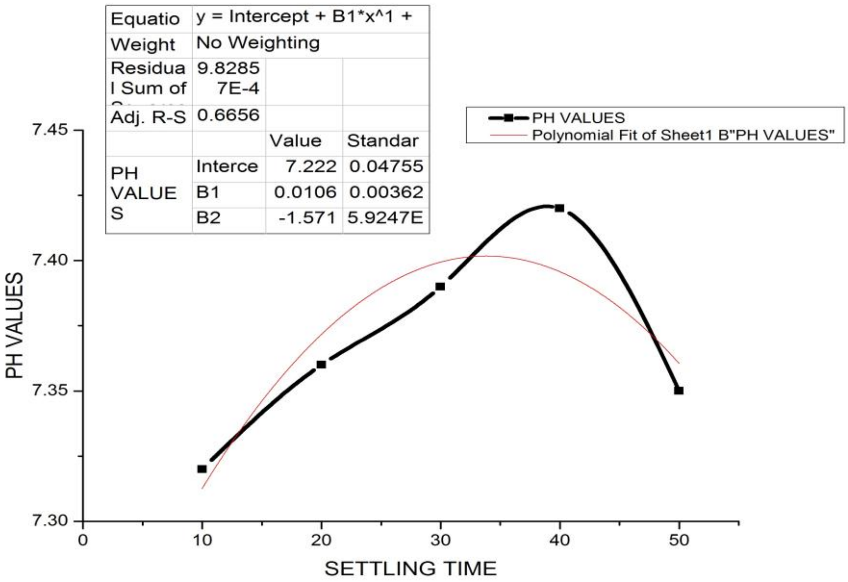

Figure 17. Effect of P^H values

The results of Hardness, TDS, and P^H obtained are shown in Table 4, Here in this study we observed that the values of TDS, and P^H decreasing up to sometime but Hardness value increases, but these value will be less when compare to ground water. And again it will increases if the settling time increases.(i.e., for 30 mins).

4.4. Experiment of Water at Pressure 7bar (sample water collected at every 10 min)

At air pressure5 bar, water circulating through a tangential nozzles is 30min and flow rate of nozzles at initial readings are Q1=22 kilo/litre Q2=27 kilo/litre

Now collect water samples for every 10, 20,30,40,50 Mins ,the results obtained for water analysis are,

Table 5: Analysis of Water at7 bar

S.No.	Settling Time, Min	TDS, mg/l	Hardness $Caco_3$	P^H
1	10	732	464	7.91
2	20	742	432	7.82
3	30	726	416	7.86
4	40	712	424	7.88
5	50	716	416	7.82

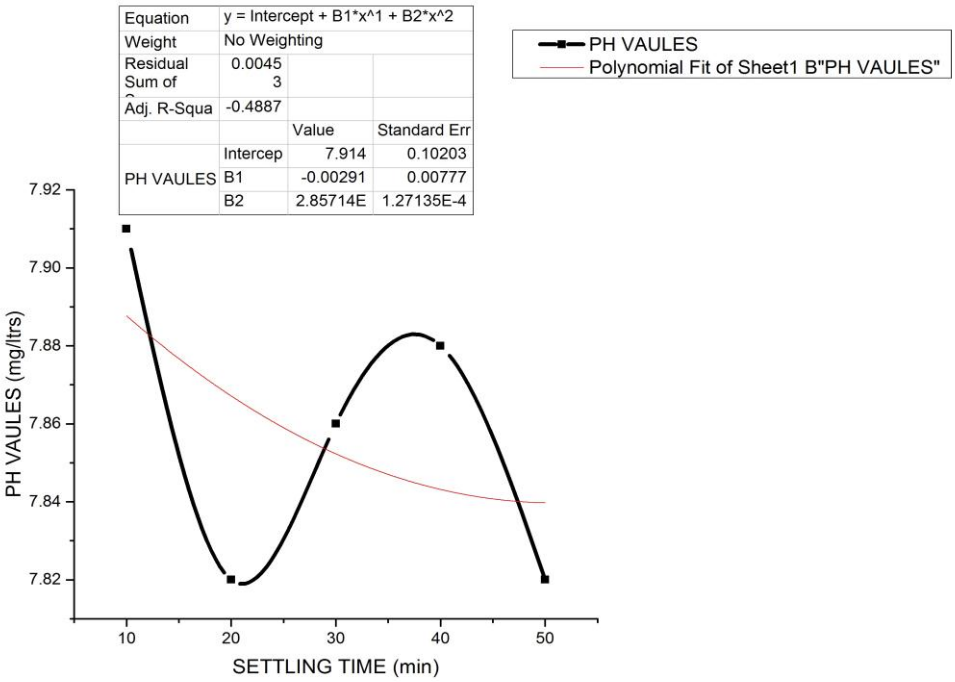

Figure 18. Effect of P^H values

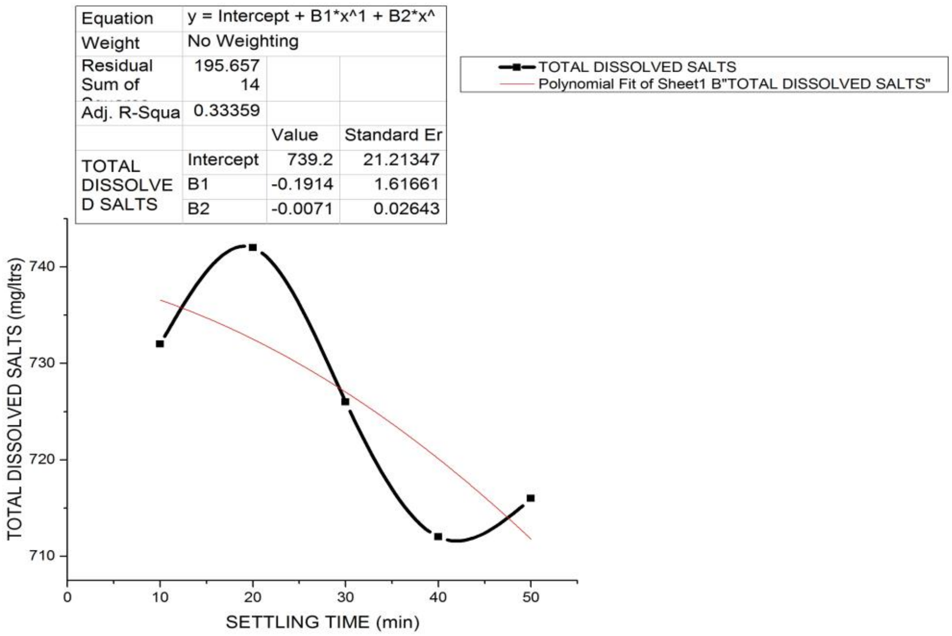

Fig 19. Effect of TDS mg/litre

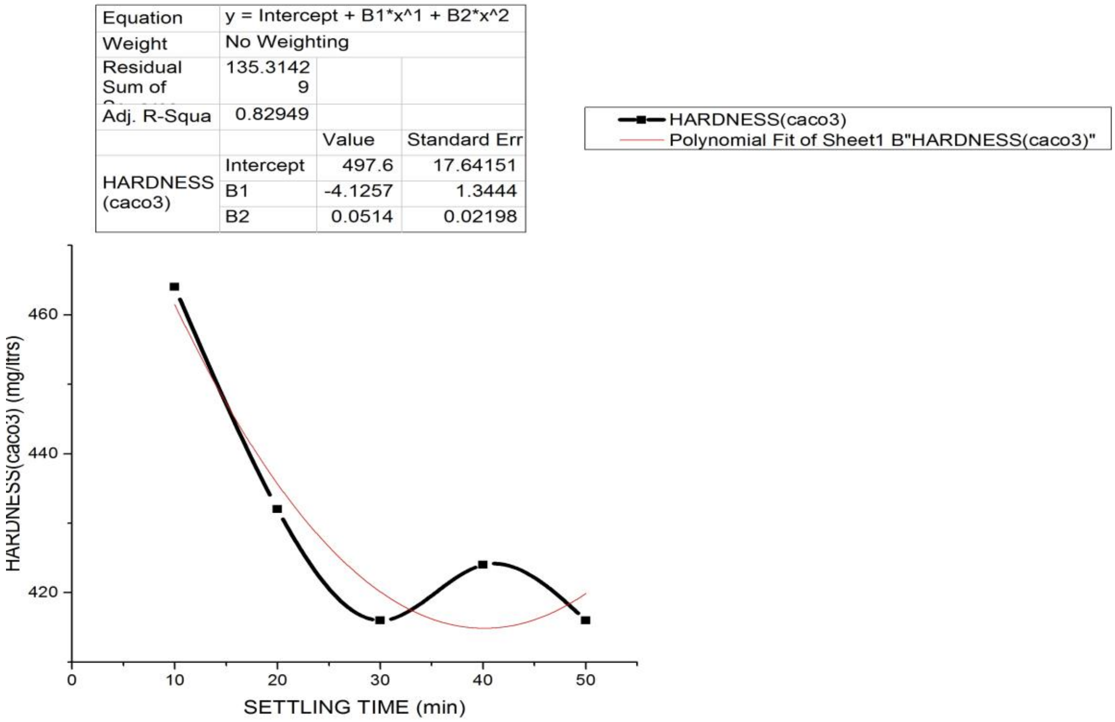

Fig 20. Effect of Hardness mg/litre

The results of Hardness, TDS, and P^H obtained are shown in Table 5, Here in this study we observed that the values of
TDS, and P^H decreasing up to sometime but Hardness value increases, but these value will be less when compare to ground water. And again it will increases if the settling time increases.

5. EXPERIMENT OF AIR PRESSURE AT 1,3,5&7BAR THE EFFECT OF TOTAL DISSOLVED SOLIDS ARE (SAMPLE WATER COLLECTED AT EVERY 10 MIN) SHOWN IN THE TABLE.

Table 5: Analysis of Water at 1,3,5&7 bar

S.No.	Settling Time, Min	TDS, mg/l 1 bar	TDS, mg/l 3 bar	TDS, mg/l 5 bar	TDS, mg/l 7 bar
1	10	810	784	758	732
2	20	802	780	756	742
3	30	804	784	758	726
4	40	808	788	770	712
5	50	804	778	766	716

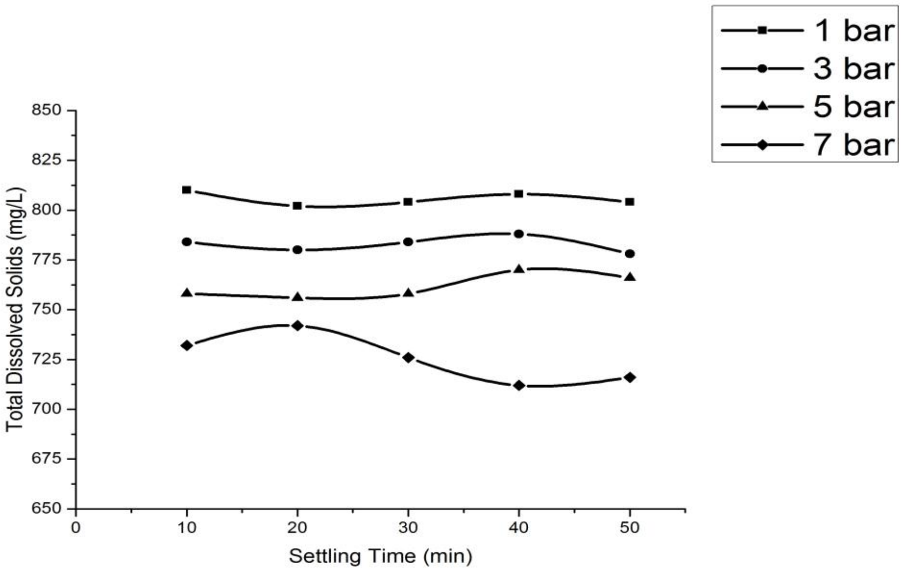

Fig 21. Effect of TDS mg/litr

From the above graph it is observed that increasing the air pressure as greater effect i.e. reducing the total dissolved solids.

CONCLUSIONS

1. By this investigation it is observed that by increasing the air pressure the only TDS is getting reduced.
2. The hardness and P^H values are reduced in comparison to that of the water as is available.
3. It is observed that air pressure as greater effect on total dissolved solids, increasing in air pressure in to the vortex tube is reducing total dissolved solids. It is also observed that increasing settlement time reduces the total dissolved solids.

FUTURE SCOPE

If oxygen is supplied to the system the water will oxidize more and the Hardness and TDS are further decreased.

REFERENCES

[1] City of San Jose, San Jose/Santa Clara" Water Pollution Control Plant", Guidelines for Managing Water in Cooling Systems for Owners, Operators, and Environmental Managers, July 2002.

[2] Cho, Y.I, Lane, J, Kim, W., "Pulsed power treatment for physical water treatment", International Communications in Heat and Mass Transfer, 32, 2005, pp. 861-871.

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

[4] 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).

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