ISSN: 0379-5462
IPPTA: Quarterly Journal of Indian Pulp and Paper Technical Association
Vol. 34, E3, 2022, p. 98-102

ENERGY AND WATER CONSERVATION IN PAPER INDUSTRY WITH POLYAMINE-BASED BOILER FEED WATER TREATMENT

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Abstract:

Energy and water play a major role in the development of the country. The need of the hour is to save both by all means. Paper and process industries are in the forefront of saving utility costs as that contributes a major share in overall cost of production. Corrosion and scaling are major threats to the steam/power generating system that would greatly increase maintenance costs. Keeping this in mind, this paper is focused on a polyamine-based chemical, a unique cost-effective boiler feed water treatment program.

Keywords: Chemisorption, Hydrophilic, Hydrophobic, Polyamines, Phosphate hide-out, Aliphatic, filming amines, Neutralizing amines, Deoxygenating agents, Complexing agents, Organic Dispersant, Blowdown, Non sticky film, drop wise condensation, LP/HP dosing, non-carcinogenic.

Introduction:

The use of polyamines is rapidly being implemented globally across multi-sector plants. Today, more than 200 customers in India are using this Polyamine based treatment and are benefiting through this. The salient features of this paper therefore are:

1 Application and advantages of polyamine treatment program - Methodology, working principles of the treatment and monitoring parameters

2 Energy & water savings - Advantages such as energy conservation, cost effectiveness and other operational benefits

3 Successful implementation - some case studies in paper industry

Material & Method – Boiler water treatment

What is meant by polyamine treatment and how does it differ from conventional treatment?

Polyamine treatment: A brief note

Polyamine treatment is a user/eco-friendly and non-toxic blend of the following functional constituents:

- Aliphatic film forming amines
- Neutralising and alkalizing amines
- Organic complexing, scale controlling, de-oxygenating agents
- Organic dispersant

It is a multi-component polyamine-based treatment program and is a single product replacement for antiscalant, sludge conditioner and oxygen scavenger

A brief note on conventional boiler water treatment and the drawbacks

Conventional treatment comprises of using multiple chemicals like phosphates, hydrazine or sulphite, sludge conditioner, etc in Boilers. Such programs have the following major drawbacks:

- **Strict Monitoring & control:** The treatment requires strict monitoring of chemical residuals and pH for its effectiveness. Chemical dosage is required in both LP & HP sides.
- **Energy loss through more blow down:** Addition of salts like phosphates leads to increased solid load on the boiler

(consequently more blow down) and can cause deposits/ under deposit problems. Make up water consumption also increases due to more blow down. Precipitated Ca/ Mg, Hydroxyapatite sludge can form hard deposits

- Phosphate hide-out: Phosphate hide-out, a frequent phenomenon in cycling boilers can lead to costly failures.
- The protective magnetite layer grows with time leading to reduction in heat transfer and can cause under deposit corrosion e.g., Caustic attack/gauging.

Working principles of Polyamine based Boiler feed water treatment

Polyamine film barrier: The aliphatic polyamine groups have a strong affinity to metals and this leads to an amine adsorption on exposed metal surfaces (Chemisorption). Filming amines present in this formulation are dehydrating agents and these amines extract the absorbed water from the metal surface and occupy the respective vacant sites forming an inhibitor film. The filming amines are large molecules having both hydrophilic (water attractive) and hydrophobic (water repellent) ends in their structures- Refer diagram 1. The film acts as a physical barrier between water and the metal surface. The hydrophobic hydrocarbon chains prevent wetting of the metal surface and protects the boiler tubes from corrosion and scale formation.

Neutralising and Alkalising Amines: The formulation also contains multiple neutralising amines with a wide range of distribution ratio, dissociation constant & Basicity to ensure protection of the entire Boiler-Turbine-Condensate system against low pH attack

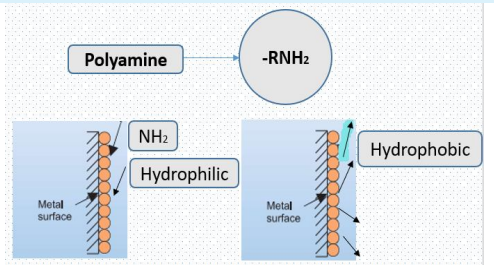
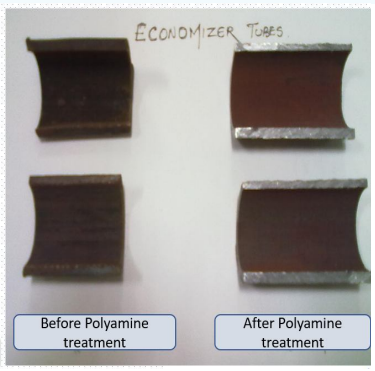


Diagram 1

Complex organics, scale controlling, dispersant and De-oxygenating agents: While deoxygenating agents provide secondary protection against residual oxygen, other controlling agents arrest crystal growth, binds silica, prevent scale formation and carry over. They also ensure that impurities are well dispersed and prevent crystalline growth to reduce scale & deposits.



Regulation of dosage: The dosage is regulated by monitoring the pH of the return condensate. The dosage should be adequate to ensure a turbine/Process/Exhaust condensate pH of 8.4 – 9 as this ensures no low pH corrosion and also that there is a residual amine in condensate to ensure protection to the post boiler/condensate system.

Formation of Amine film: The formation of a non-sticky amine layer on the metal surface had been confirmed by a team of research scholars (B Allard et al) who had carried out an extensive study on the filming amines and its application in boiler feed water conditioning. The formation of continuous filming amines on the wetted metal surfaces has been verified in Laboratory examinations of specimens taken from economiser tubes. Surface coatings visible in Scanning Electron Micrographs (SEM) were analysed using Electron Spectroscopy (ESCA) and Secondary Ion Mass Spectroscopy (SIMS) and the organic nature of these films as well as the presence of nitrogen adjacent to the metal surface were confirmed (Reference: 1)

Conventional vs polyamine treatment at a glance

S.No	*Polyamine treatment*	*Conventional treatment*
1.	Single chemical	Multiple chemicals
2.	Liquid, easy to handle	Both Liquid & solid chemicals are used
3.	Only LP dosing	Both LP and HP dosing
4.	"Zero" solid treatment program	TDS increases in conventional treatment
5.	Reduces blowdown	Higher blowdown

S.No	Polyamine treatment	Conventional treatment
6.	Substantial energy savings and reduction in makeup water consumption	Relatively more energy and water consumption
7.	Protection is given by filming amines which protects Preboiler, boiler and post boiler sections	Protection is given by chemical reaction and only limited protection to condensate system against low pH corrosion
8.	Simple monitoring parameters	Needs frequent checking. Parameters like residual phosphate needs to be checked regularly

Results & Discussions

Why to prefer polyamine treatment to conventional treatment?

There are substantial benefits that necessitates the powerplant Manager to go for polyamine treatment. The operational and monitory benefits have been summarised below:

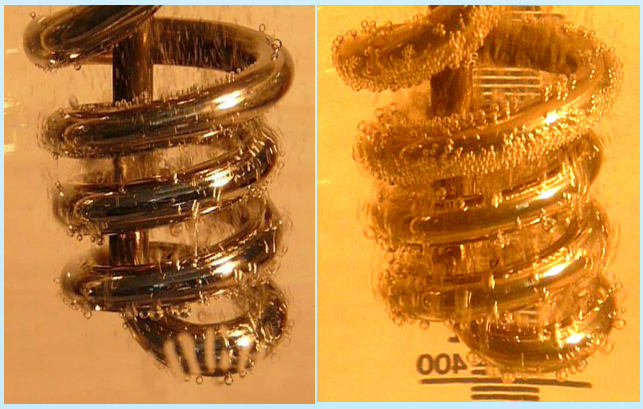
Operational benefits

Single product, Cost effective treatment

It is a safe, non-toxic, easy to handle product. As the dosing of polyamine is only on the LP side, it is easier to dose, monitor and control. The HP dosing chemicals are not required and thus the energy costs being incurred for the HP dosing system can be saved.

Improved heat transfer

Due to the non-wettable nature of the film, drop-wise condensation is promoted. As the thermal resistance of the filming agent is less than that of the normal condensate film, an increase in heat transfer is achieved (For a typical paper machine dryer, Thermal conductance/Heat transfer coefficient: Before polyamine treatment – 123 Btu/hr/sq.ft/F, After polyamine treatment – 288 Btu/hr/sq.ft/F)



Easy monitoring parameters

It is sufficient to check the pH, conductivity/TDS and silica in feed, condensate, blow down & DM/MB water samples on regular basis. Iron and related parameters can be checked once a week or so.

Monitory benefits

Energy and water savings

This is 100% organic formulation and thus there is no contribution to TDS by its addition to the system. Therefore, the boiler water TDS levels can be maintained with lesser blow down as compared with phosphate-based treatment. Consequently, the make-up DM water consumption will also come down which ensures overall savings in boiler operation costs (Further details have been provided in the case studies given below). It is a user-friendly treatment with quick ROI.

Increase in Turbine efficiency

Boilers operated on phosphate treatment have the potential of carryover of phosphates to the steam going to turbines. These phosphates in steam have high probability of deposition on blades of the turbines, which can result in marked efficiency reduction of the steam turbine. The aliphatic polyamine-based chemical does not contain phosphate which results in cleaner turbines, thus maximising turbine efficiency. Further the non-sticky polyamine film keeps the TG blades clean.

Savings in repair cost

As the polyamine treatment provides fool proof protection to pre-boiler, boiler and post-boiler sections, it ensures trouble free operation. Hence, the user can incur substantial savings towards repair/maintenance cost. (More benefits have been mentioned in the case studies)

Case studies

Case Study 1: One of the paper mills in Western India using polyamine based water treatment for more than a decade. having two boilers with steam generation of 25TPH and pressure of 44 Kg/cm^2. The treatment is well established and no problem has been reported till now. Prior to polyamine treatment, more water consumption and frequent pinhole leaks in economizers had been reported. The problem has been set trait by switching over to polyamine treatment.

Parameters		***Phosphate treatment (Before polyamine)***	***During Polyamine treatment***
Feed Water			
pH		8.8 - 9.45	8.9 - 9.2
Total Hardness		Nil	Nil
Conductivity	µS/cm	4 - 4.5	5 - 6
Silica as SiO_2	ppm	<0.02	<0.02
Boiler CBD water			
pH		9.5 -10.1	9 - 9.2
Conductivity	µS/cm	**50 - 60**	**8 - 14**
Silica as SiO_2	ppm	**2.2 – 3.0**	**0.8 – 1.2**
Blow Down	TPD	**25 TPD (Avg)**	**10 TPD (Avg)**
S/H Steam			
pH		9.12	9.10
Conductivity	µS/cm	7	4-5
Silica as SiO_2	ppm	<0.02	<0.02

Energy savings due to blowdown reduction with polyamine treatment equivalent to steam= 6 Tons per day

Case Study 2: A pulp and paper mill in vietnam (Near Hanoi) is using the polyamine based water treatment more than 10 years (steam generation of 90TPH, 63 Kg/cm^2). The treatment is very well established.

Prior to polyamine treatment, the quality of steam was not upto the mark due to carryover. Further, there was coloration in the blodown indicated that the internals have been corroded. The problems have been rectified after starting polyamine treatment.

Parameters		***Phosphate treatment (Before polyamine)***	***During Polyamine treatment***
Feed Water			
pH		8.8 - 9.6	8.7 - 9.2
Total Hardness		Nil	Nil
Conductivity	µS/cm	3 - 5	4 - 6
Silica as SiO_2	ppm	<0.02	<0.02
Boiler CBD water			
pH		9.7 -10.1	9 - 9.2
Conductivity	µS/cm	**45 - 90**	**10 - 14**
Silica as SiO_2	ppm	**0.64 - 1.3**	**0.4**
Blow Down	TPD	**30-70 TPD (Avg)**	**12-20 TPD (Avg)**
S/H Steam			
pH		9.12	9.0
Conductivity	µS/cm	10	4-5
Silica as SiO_2	ppm	<0.08	<0.02

Energy savings due to blowdown reduction with polyamine treatment equivalent to steam= 15 Tons per day

Case Study 3: One of the paper mill in Eastern region using the polyamine based water treatment more than 10 years in their boiler with capacity having boiler with steam generation of 26 TPH and pressure of 65 Kg/cm^2. The treatment is well established.

Prior to polyamine treatment, frequent HP dosing pump failures, higher phosphate levels in the drum at times lead to scaling and phosphate hide out issues. Treatment was started in 2014 and after switching over to polyamine-based treatment the above problems have been rectified.

Case Study 4: One of the paper mill in southern region using the polyamine based water treatment more than 5 years in their recovery boiler with capacity having boiler with steam generation of 120 TPH and pressure of 65 Kg/cm^2. The treatment is very well established.

Prior to polyamine treatment, Heavy blowdown was given due to higher TDS in the blowdown, wheel chamber pressure was high due to scaling issues in their turbine, which resulted in frequent stoppages of boilers. After starting the polyamine treatment, blowdown has been substantially reduced and further it has been observed that the treatment helps in efficient soot blowing.

Parameters		Phosphate treatment (Before polyamine)	During Polyamine treatment
Feed Water			
pH		8.8 - 9.0	8.7 - 9.2
Total Hardness		Nil	Nil
Conductivity	µS/cm	4 - 4.5	3 - 5
Silica as SiO_2	ppm	<0.02	<0.02
Boiler CBD water			
pH		9.5 -10.	9 - 9.2
Conductivity	µS/cm	**35 - 45**	**10 - 15**
Silica as SiO_2	ppm	**0.8 - 1.3**	**0.4 – 0.8**
Blow Down	TPD	**25 TPD (Avg)**	**10-15 TPD (Avg)**
S/H Steam			
pH		9.5	9.10
Conductivity	µS/cm	7	4.0
Silica as SiO_2	ppm	<0.02	<0.02

Energy savings due to blowdown reduction with polyamine treatment equivalent to steam= 20 Tons per day

Case Study 5: One of the paper mills in north region using the polyamine based water treatment more than 15 years in their boiler with capacity having boiler with steam generation of 60 TPH and pressure of 65 Kg/cm^2. The treatment is very well established.

Prior to polyamine treatment, heavy scaling in TG blades was found due to high silica carryover and there were heavy fluctuations in water parameters which resulted in frequent stoppages of plant. After starting the polyamine treatment, the problems have been rectified.

Boiler CBD water			
pH		9.5 -10	9 - 9.2
Conductivity	µS/cm	**60 - 80**	**15 - 20**
Silica as SiO_2	ppm	**2.0 - 3.0**	**0.8 – 1.5**
Blow Down	TPD	**40 TPD (Avg)**	**15-20 TPD (Avg)**
S/H Steam			
pH		9.5	9.10
Conductivity	µS/cm	15	5-8
Silica as SiO_2	ppm	<0.08-0.14	<0.02

Energy savings due to blowdown reduction with polyamine treatment equivalent to steam= 9 Tons per day

Conclusion

It is now widely accepted that the polyamine-based treatment offers several benefits over phosphate-based treatment and the same has been recognised by Confederation of Indian Industries (CII). The increasing number of customers is evidence that it has proved to have a clear edge over other treatment and has carved a niche in boiler water treatment program.

Acknowledgements

The authors would like to thank the staff and management of Elof Hansson (India) Pvt. Ltd for their valuable support. The authors also wish to express their gratitude to IPPTA for providing an opportunity to share their experiences in the boiler feed water treatment program.

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