Enviro-Friendly Nansulate Coating for Select Applications in Seshasayee Paper

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ABSTRACT

An Innovative scheme using Nanotechnology integrating Corrosion mitigation with low temperature heat containment had been developed specifically for use in Paper mills. The specialty of Nansulate® coating which had innumerable successful heat recovery case studies to its credit is planned to be extended to hitherto untried applications in Seshasayee Paper and Boards Ltd. The paper highlights the protective feature of corrosion mitigation in one case and yet effecting energy transfer and Carbon emission reduction in low end heat recovery in other case. The case study is unique in that Nansulate® concept is being initiated in stack of Coal fired Boiler with the singular objective of corrosion prevention of the base material. The other case study relates to efficient heat containment and CUI prevention in chiller unit of ClO_2 plant with Nansulate® coating application. The combined success of Nansulate® would probably be ***the*** answer for Corrosion mitigation alongside heat recovery in industries in general and Paper and Pulp mills in particular, thereby targeting the 3 Es Energy Conservation , Environment Management and Emission Reduction, all in one.

Introduction

Reducing Production costs and environmental impact with sustainability strategies on a continuous basis is a challenge that many industries in general and paper mills in particular face on a daily basis. When it comes to thermal insulation, though attention is being paid to low energy heat containment which otherwise is wasted to the landscape, invariably the adverse environmental impact on the base metal substrate is ignored . Insulation of heated as well as chilled equipment is an area wherein both energy conservation as well as environment management does play an important part as will be seen from the paper.

Latest advances in Nanotechnology in the style of nanocoatings offer a way to thermally insulate, prevent corrosion from humid environment and Corrosion Under Insulation (CUI) and thereby extending the longevity of the base material carrying the fluid and ensuring operator safety.

The patented nanotechnology based coating , called Nansulate® developed by Industrial Nanotech Inc. USA has established itself as No. 1 insulator all the world over. Apart from thermal insulation, it also protects the base equipment from corrosion , thereby enhancing asset longevity. In addition to its long term durability and consistency of insulating ability in terms of lowering energy consumption and related carbon emissions, the ability of Nansulate® to withstand environmental impact under adverse conditions is being taken up in this paper. The dual function of Nansulate® is being brought out through the case studies presented in the foregoing sections.

To begin with, Nansulate® , spray-on thin film application can be applied to any substrate (uniform as well as non-uniform) effortlessly with minimal disruption of production activities. Insulator ensures minimization of heat transfer from hot fluid to atmosphere or from ambient to chilled fluid (Fig.1). The water based Nansulate® coating is the state of the art low conducting material in coating form (Fig.2) [1]. Nansulate® has the lowest thermal conductivity and hence is categorized as the best thermal insulator (Fig. 3) [2].

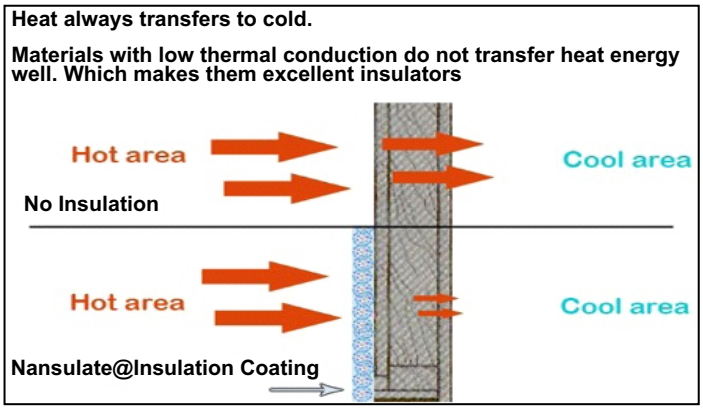

Fig. 1 Heat Flow Trajectory for Heating as well as Chilled units

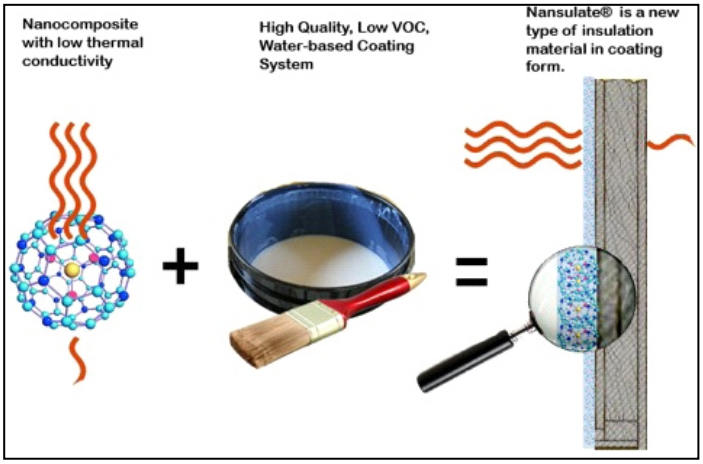

Fig.2. Snap Shot of Nansulate® formulation

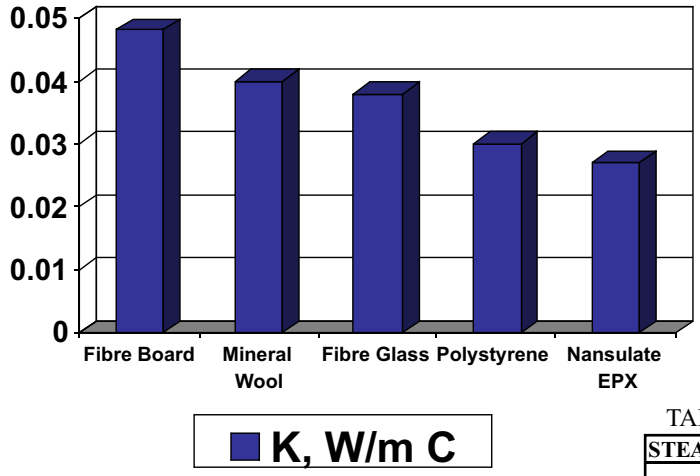

Fig. 3. Thermal Conductivity [K] of Insulating Materials A Comparison

For ready reference , the advantages of Nansulate® are enumerated in Table -1. The unique specialty of Nansulate® is one of mitigation of CUI as also resistance to harsh and humid environment envelope.

TABLE 1

ADVANTAGES OF NANSULATE®

- Low VOC, Odour & Non-Toxic, Water based
- Excellent Chemical Resistance to acids & bases
- Corrosion under insulation minimal
- Severe Service durability
- User friendly
- Green Nano-technology
- Steam saving through reduction in radiation loss
- Assured Carbon footprint (CFP) reduction
- Very Low thermal conductivity and hence excellent insulator
- High pull-out ability
- Abrasion resistant
- Clear Visibility of base surfaces
- Can be applied in non-uniform profiles
- Space occupancy & weight addition minimal

Of the Diverse Application areas of Nansulate® coating (Table-2),the case studies taken up for illustration bring to the fore the above unique characteristics dovetailed to wasted energy loss minimization and hence attendant Carbon emission reduction.

TABLE 2

APPLICATION AREAS OF Nansulate® IN PULP & PAPER MILLS

- Paper Machines Drying Cylinder end Cover, Scanner proximity
- Hot / Warm Water and Process Fluid Lines
- Steam turbine condensate lines and Oil Coolers
- Low Pressure (4.5 bar) Steam Pipelines & Accessories
- Medium Pressure (11 bar) Steam Pipelines & Accessories
- Heat Carrying Connectors, Valves & Fittings
- Heated HFO lines & storage tanks
- Chiller lines in ClO_2 unit Bleaching Unit of Fiberline
- Plate Heat Exchanger End Covers related to HRU of CPU & EOP units

Case Study -1

High Pressure AFBC Boiler Firing Imported High Moisture Lignitic Coal

The atmospheric fluidized high pressure boiler (Table -3) is firing high moisture coal (Table - 4) imported from Indonesia for generating high pressure steam related to the Double extraction Condensing steam turbine for producing power and low pressure steam for process use.

TABLE 3 AFBC Boiler [#10] STEAMING SPECIFICATIONS

STEAMING CONDITIONS	VALUE	UNITS
Design Steam evaporation rate	117	TPH
Economic continuous rating	85 to 105	TPH
Steam outlet pressure	106	ATA
Steam outlet temperature	510	°C
Steam temperature control	65-100	%
Feed water inlet temperature to Boiler Feed Pump	135	°C
Fuel	Imported Coal	

TABLE- 4 Coal Analysis

Source: Imported Coal (Indonesia)

A.Proximate Analysis

		As Fired	Dry Basis	Dry Ash Free
Moisture	%	26 to 32	-	-
Ash	%	3 to 5	4 to 7	-
Volatile Matter	%	33 to 36	47- 50	51
Fixed Carbon	%	32 to 35	45 -46	49
GCV	kcal/kg	4500 – 5050	6600 - 6900	7000-7100
Sulphur	%	0.3 to 0.8		

B. Hardgrove Index: 48 - 50

The flow chart depicting the various sections in place is elicited in Fig. 4. The warm flue gas after giving its heat to the combustion air in flue gas air preheater at the back-end is passed through Electrostatic precipitator for dedusting, before it is led through the 82 metre high concrete stack to the environment through the help of I.D. fans.

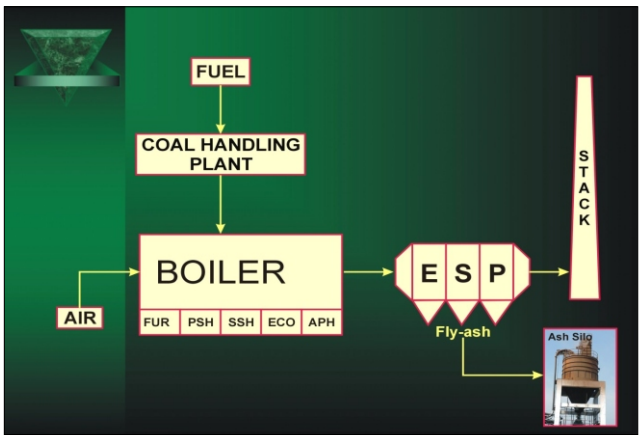

Fig. 4 Flow chart of AFBC High Pressure Boiler

Flue gas quantity measured at ESP outlet is 40 to 45 Nm^3/s at 132°C . With 3 field dust collection efficient ESP in place, the SPM level is at a low of around 20 mg/Nm^3 [3]. Typical flue gas analysis is elicited in Table 5.

TABLE -5 Flue gas analysis

Constituent	Value
CO_2	12 to 13 %
O_2	6 to 7 %
CO	<200 ppm
SO_2	< 300 ppm
NOx	< 400 ppm
N_2O	< 20 ppm

It is standard practice as per the directive of PCB to install cone at the stack exit for increasing the dispersion of suspended particulates through increased flue gas velocity. Though the flue gas temperature is at a safe temperature of around 140°C at APH exit, the gas temperature leaving the stack would be lower, say 110- 115°C with total moisture in flue gas of around 8 %. Hence with this high moisture flue gas, there is bound to be acidic condensation leading to cold end corrosion of the metallic cone, more so with still higher temperature drop due to lower flue gas velocity inside the tall stack (Fig. 5).

It has been decided to try out Nansulate® coating over the metallic substrate (to serve as stack cone), primarily with a view of alleviating the corrosion of the base metal substrate [4]. Towards that, metallic substrate (using mild steel as MOC) cone had been fabricated in house in SPB Workshop (Fig.6).

Fig.6. Fabricated M.S. Stack Cone parts

Special Nansulate® compound had been imported from Industrial Nanotech Inc. USA, for applying the same as spray over the steel cone on the ground itself. The test result related to Pull-off ability of the coat on the substrate as made available by R&D Centre of Industrial Nanotech , USA is elicited in Table 6 [4].

TABLE 6 Special test results related to Nansulate®

Parameter	Standard	Value
Pull-off Strength	ASTM D -4541	2450 psi (175 ksc)
Cross hatch adhesion	ASTM D-3359	0% 5B, edges remain smooth, no flaking.
Fog corrosion test		Completed 24 cycles
u/v exposure		Passed 2000 hours
Flame spread	ASTM E84	Class A
VOC CONTENT		60 – 100 g/l
Coating base		Water – non –toxic
Colour/opacity	<80°C ; >80°C	Translucent.(Clear) White (opaque)
Moisture resistant		Very high
Chemical resistance to acids, bases & salts		High
Climate friendly		Does not contain negative GWP or ODP ingredients

Fig. 5. Enmas AFBC Boiler with Stack(inset) in the background

With dedusted flue gas containing traces of fine particulates and with SO_2 /SO_3 in limited amounts and at 8 % moisture content level would be flowing past the stack cone at a reasonable velocity of around 8 to 10 m/s. This particular long term study planned is one of endurance ability of Nansulate® in protecting the base metallic substrate from cold end corrosion and yet keeping the coating in place through high adherence ability inspite of flue gas flowing across the cone at a distinct velocity on a continuous basis. The study is first of its kind in showcasing the properties of Corrosion mitigation and base metal substrate longevity.

Case Study Chilling Section insulation in ClO_2 Plant

Like most other pulp mills, SPB had originally used elemental chlorine as a bleaching agent. Because of environmental concerns regarding the effluent, this mill has converted to an Elemental chlorine-free (ECF) bleaching operation. The process designed by ERCO , Canada, uses chlorine di oxide as a bleach agent because of its excellent environmental compatibility and bleaching efficiency. Because of its chemically unstable nature , ClO_2 for the bleach solution generated at the site in a chemical process needs low temperature to remain in solution. At temperatures above 11to12°C , ClO_2 does not readily absorb into solution , dramatically reducing the effectiveness of the chlorine di oxide production process [5]. This is where vapour absorption chiller fits in.

The 10 tpd ClO_2 unit , designed, engineered and supplied by ERCO uses chilled water at 7 to 8 °C for ClO_2 absorption . The paper mill had gone in for Thermax designed Vapour absorption chiller of 460TR capacity for chilling 50 m^3/hr water from say 30/32 °C to 6/ 7°C (maximum : 8°C). Medium pressure steam at 10 bar is used to operate the VAM unit. In VAM unit, care had been taken to go in for cupro-nickel tubes to resist pitting and corrosion

Around 40 m^3/hr clarified fresh raw water at over 30°C as available, is chilled to the desired temperature of <10°C . The excess chilled water not used for ClO_2 absorption is returned to an intermediate chilled water storage tank. The incoming ambient water is mixed with the chilled water excess. The water at around 18 to 20 °C from the chilled water storage tank is pumped through secondary chilled water pump to VAM unit for chilling to the desired temperature. Of late with chilled water at a higher temperature (9 to 10° C), the absorption of ClO_2 needed more steam consumption. The heated as well as the chilled fluid carrying lines and holding tanks are protected by conventional Rock wool insulation mattress encapsulated by aluminium cladding.

As few of the chilled water lines and enclosures were exposed and not totally insulated, it has been decided to go in for Nansulate® coating ,wherever required. To start with the Chiller cover of VAM and Stainless steel connector relating to chiller water pump had been coated with Nansulate® and is under observation for the past fortnight. As the surrounding environment around the chilled water lines and VAM unit is laced with mild ClO_2 atmosphere , Nansulate® shall be tested for protection of the stainless steel connector from the surrounding environment and mild humid atmospheric corrosion.With Nansulate® coating, the lowering of chilled water temperature is expected to ensure effective ClO_2 absorption and marginal MP steam saving. An expected saving of 4 to 5 TPD of steam would translate to marginal carbon emission reduction of ~1000 TPA .

For conventional insulation at low temperature , since the insulation of equipment and pipe-lines less than 10 ° C, to prevent penetration of water vapour into the conventional insulation mattress and to avoid serious corrosion, water accumulation and water in humid air condensing on insulation , vapour barrier in the form of foils is advocated. Inspite of all of these, insulation mattress losing its effectiveness through humid air leaking through the seal and uninsulated equipment is unavoidable. With Nansulate®, the above problem does not occur , as can be seen from the next section.

Corrosion Under Insulation (CUI)

CUI is a localized corrosion occurring at the interface of the base metal substrate and the insulation material on that surface. The closed environment of the insulation material over the pipe, tank or equipment under review and sealing the insulation with cladding wrap creates condition that leads to moisture/vapour build up and resultant corrosion . The corrosion is very severe due to the insulation and the cladding not allowing evaporated vapour to escape to the surrounding environment; The insulation thus acting as carrier for moisture movement from one area to the other within the insulation matrix causing the corrosion to spread ever so rapidly. (Fig. 7) [6].

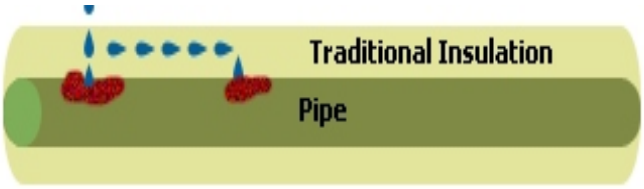

Fig. 7 CUI in Conventional Insulation Material

Clear Visibility

The clear appearance of the coating (after curing period completion of 4 weeks) makes visual inspection possible without damage to or removal of the coating (Fig.8).

Fig.8 Chilled Water Pump SS Connector with NS Coating

In this study, the combination of energy saving, increased efficacy of ClO_2 solution and corrosion resistance from within as well as from outside is a nanotechnology innovation

Case Study Steam Encapsulated Equipment With Nansulate®

For the sake of completeness, it is worthwhile recapitulating the thermal energy gains obtained with Nansulate® coating of Dryer ends (Fig.9)and scanner proximity related to Paper Machine (PM -5) [1] . The surface temperature drop recorded in Dryer -12 ends was around 30°C (145 to 115 °C). (Table-7). Through coating with Nansulate® of the sections in scanner proximity (PM-5), the lowering of temperature from a high of 65 °C to a comfort level of under 48 °C , ensured proper functioning of the scanner.

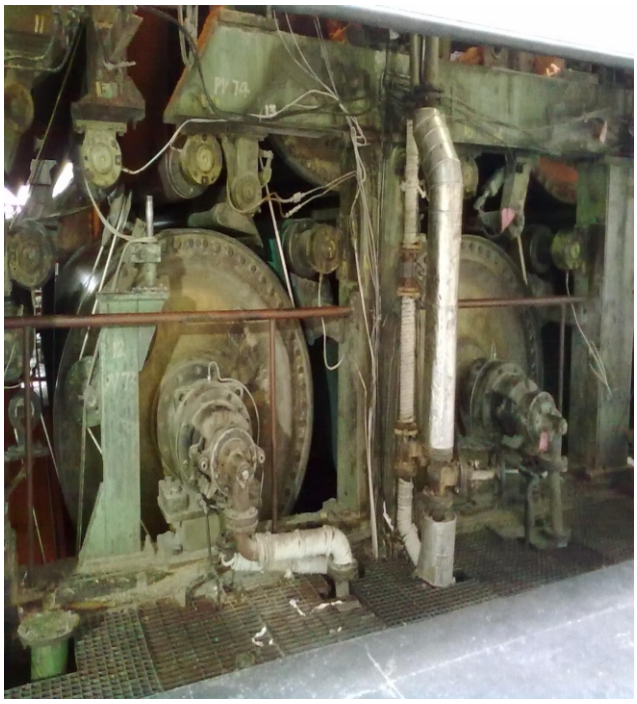

Fig. 9. Drying Cylinder # 12 & # 14 of PM-5

TABLE 7
Results with NANSULATE Coating on Dryer # 12 end cover of PM-5

Location	Uncoated surface temperature	Coated surface temperature	▲T
	°C	°C	°C
A	145	120	25
B	143	117	26
C	145	115	28

Schemes on the Anvil

- Both MP (10.5 bar) as well as LP (3.5 bar) steam pipe-lines and the associated valves and fittings from Boiler House to the Paper Machines would have first 2 to 3 coats of Nansulate® coating followed by conventional high density Rock-wool insulation and finally wrap by Aluminium cladding as before. This would result in dual gains viz., protection of base metal substrate from CUI and reduced insulation thickness cover (thus effecting reduced weight and space occupancy) where space is at a premium [4].
- The bare 82 metre long Rotary Lime Kiln operating in the open environment subjected to wind sweep, is invariably left un-insulated. Radiation & Convective Losses are of a high order leading to significant high cost furnace oil consumption. Plans are on the anvil, to go in for few coats of Nansulate® coating of the kiln shell exterior at the lime mud feed end to start with [4], in order to gain confidence and later gradually enter the drying section of the lime kiln shell exterior with NANSULATE coating application. The objective of the above exercise .is to effect reduction in fossil fuel consumption.

Carbon Emission Reduction

Carbon emission reduction is achieved on a continuous basis through Nansulate® high quality insulation material on a sustained basis.

Conclusion

This paper had laid emphasis on select schemes with Nansulate® application which are unique and had been successfully implemented in Seshasayee Paper Mill. Through adoption of the case studies detailed in this paper, the gains which are continuing as on date can be summarised as under:

a. Energy Conservation & Corrosion Mitigation

Nansulate® serves dual purpose of capture of otherwise wasted thermal energy to landscape as well as shielding the base metal substrate from corrosion. The nanotechnology coating is an ideal insulator for equipment carrying chilled fluids. CUI avoidance and energy saving apart, it resists external corrosion due to humid ambient.

b. Environment & Material Management

Application on non-uniform heated surfaces ensures operational safety. Low VOC level and odour add on to environmental friendliness. Low cost instead of exorbitant high cost material could be gone in for as Nansulate® takes care of corrosion mitigation. Corrosion allowance to the base material can be minimized thereby lowering material usage.

c. Emission reduction

With saving of energy which otherwise is wasted, carbon footprint is certainly lowered (though marginal in some cases) on a sustained basis, thus contributing to Carbon emission reduction.

With abated interest, the R& D fraternity of Industrial Nanotech Inc. USA , involved in the development of Nansulate®, is looking forward to the feed back from the Nansulate® coated stack cone (in place) during the coming months. The schemes on the anvil, planned for the future hold a very bright future for Nansulate® technology.

Acknowledgment

The author gratefully acknowledges the management for all the encouragement provided for implementation of the case studies depicted in this paper.

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