Identification of leakage in plate type Air Preheater using ultraviolet light test

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Abstract

In era of globalization and competitiveness, it has become important to run the industry either uninterruptedly or reducing the shutdown time of equipment/plant. This will not only increase the profit of company but also reduce the maintenance cost to a great extent. NDT plays a major role to reduce the breakdown/shutdown time of equipment and thereby of plant.

GNFC, a fertilizers and chemicals company, has established a well organized, fully fledged NDT laboratory to check the condition of any equipment and help the maintenance to carry out maintenance in more planned and organized manner with a view to reduce shutdown time.

A reformer, with air and gas circuits, is provided in Synthesis Gas Generation Unit plant. Passing of air was reported by operation group with an air leak rate of 2600 nm3/Hr from air path to gas path. It was judged that air was leaking only from plate type Air Preheater. There was no popular and established NDT method available to check the leaky area in plate type heat exchanger. GNFC has developed a complete test method using company developed fluorescent powder to identify the leaky locations in plate type Air pre-heater. A successful implementation of this innovative test method has reduced the leak rate from 2600 nm^3/hr to 500 nm^3/hr. This has postponed the management decision of replacing Air Pre-heater, costing Approximately Rs. 65 Millions.

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1. Introduction:

- **Process Overview:**

  GNFC has Synthesis Gas Generation Unit (SGGU) plant, which was installed in 1998. A reformer is used for generation of reformed gas in SGGU plant.Natural gas and steam are being used to produce reform gas in this reformer unit. However, the reaction of natural gas and steam is endothermic in nature. Hence, it needs additional heat. This heat is supplied from 20 top fired burners which maintain @875^0C temperature in the reformer house. These burners use flue gas and hot airas row materials.

  The hot air needed for combustion in burners is being supplied from Forced Draft Fan (FD Fan, C-3403). The air from FD Fan passes through plate type Air Preheater where it achieves temperature of @460^0C. This hot air supplied to burners where it ignites natural gas and finally produces combustion gas which supplies heat to reformer gas through reformer tubes. This combustion gas leaves reformer house and

passing through numbers of heat recovery units. Finally, it passes through Air Preheater and vent in to atmosphere (Stack, S-3401) using Induced Draft Fan (ID Fan, C-3402). Schematic diagram of process overview is as shown in Figure-1.

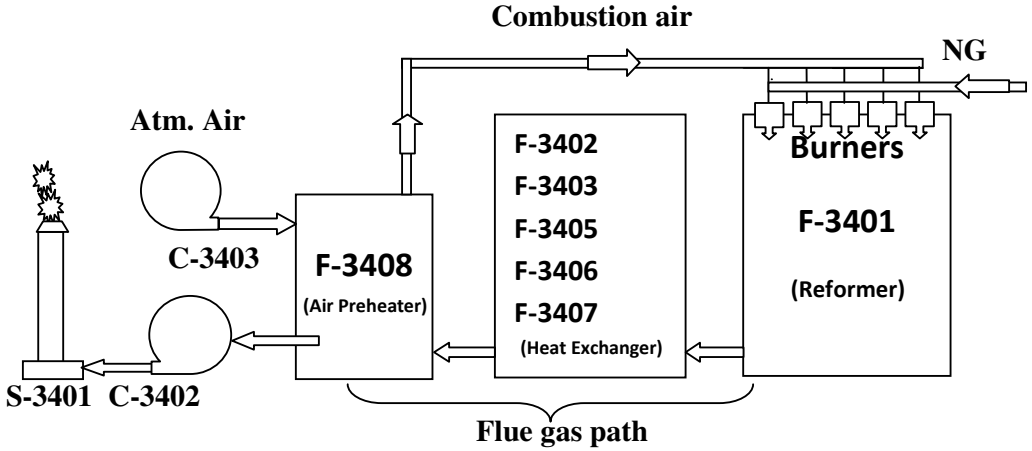

Figure-1: Schematic diagram of process overview of Reformer

- **Plate Type Air Preheater Detail:**

Pre-heaterTag No.	- F-3408
Service	-Atmospheric Air & CombustionGas
Nos. of modules	- 05
Air inlet temperature	- Atmospheric
Air outlet temperature	- 460^0C
Flue gas inlet temperature	- 480^0C
Flue gas outlet temperature	- 160^0C

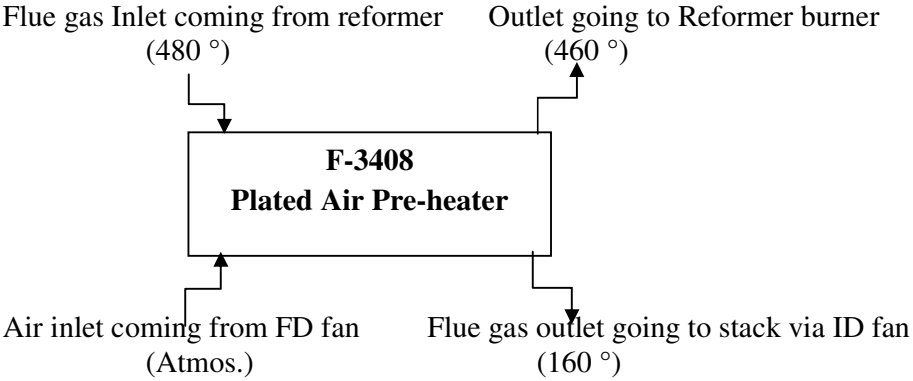

Figure-2: Schematic diagram of air & flue gas circuits in Air Preheater

- **Failure history:**

Plant operation group noticed high air consumption in the system in 2012. Temperature drop of outlet air in Air Preheater was @20^0C also reported. Hence, One by one all unit operations checked for probable cause of high consumption of air. Finally, it was anticipated that air is short circuiting in Air Preheater.

Damageanticipated in Air Preheater which allows atmospheric air to short circuit to ID Fan through leaky module. This affects the complete process of plant in following ways:

- Heat loss in air pre-heater (Reduced efficiency of Air preheater)
- Increased load of FD fan
- Increased load of ID fan
- Increased NG consumption for flue gas in burner

A necessary simulation and back calculations were carried out before inspection and repair of Air Preheater. The report shows that leaked air flow was 2600NM^3/Hr.

There was no popular and established NDT method to check the leaky area in plate type heat exchanger. A complete test method, using company developed fluorescent powder,was developed to identify the leaky locations in plate type Air Preheater.

SGGU FG CALCULATION FOR 18 Jan 2014

Remark

1 Calculations are based on point readings of 18 Jan 2014
2 Air flow and leakage air are back calculated based on O2 in FG -lab analysis
3 Air flow and hence FG flow and composition will depend on accuracy of O2 analyzers
4 Lab analysis considered as dry basis
5 CA air indicated is @ 41050 Nm3/hr which seems to be on lower side
6 Indicated fuel NG was with MW in DCS as 20.86 whereas operating NG had MW 16.2, corr applied
7 Indicated fuel PG was with MW in DCS as 7 whereas operating PG had MW 6.52, corr applied

Calculated Resuts

NG Fuel (MW corrected)-	NM3/hr	3466
PG Fuel (MW corrected)-	NM3/hr	3481
CA flow to match O2 at u/s of APH	NM3/hr	49000
Leak air flow to match O2 at d/s APH	NM3/hr	2600
Total CA flow	NM3/hr	*51600*
Calulated FG Flow	NM3/hr	57057

CALCULATION

			DCS data	Cal data	
NG Fuel	FI 3415	NM3/hr	3055	3466	MW corr
PG to burner	FI 3419	NM3/hr	3360	3481	MW corr
CA to burner (FI 3416)	FI 3416	NM3/hr	41050	51600	
FG I/L	TI 3423	°C	489.7	**502.5**	(Varied for heat bal)
FG O/L	TI 3429	°C	182.8	182.7	
CA I/L		°C	25.3	25.3	
CA O/L	TI 3430	°C	419	**406**	(Varied for heat bal)
Leakage Air to match AI 3412		NM3/hr		**2600**	
FG Analysis(Dry Basis)			**Lab**	**Cal**	
APH u/s O2		mole %	2.2	2.2	
APH u/s CO2			9.8	*9.3*	
			3.2	3.2	
			8.8	*8.7*	

2. Preparation of fluorescent powder:

R & D Department had prepared fluorescent powder using Alkaline earth oxide and Organic quinoline. Organic quinoline was dissolved in Methanol. This dissolved quinoline mixed with Alkaline earth oxide powder. Weight of Organic quinoline was kept 5% to 10% of total weight. Then mixer was dried in oven at 50^0C ~ 60^0C temperatures for 4 to 5 hours. After drying, mixer was grinded in grinder to reduce the mesh size to the possible extent and to break the pallets. Mesh size of this florescent powder was below 100 micron. The powder was also manufactured with a property such that it will show of green colour in ultraviolet light.

3. Innovative NDT procedure:

A hole of 2" dia. was made, to charge fluorescent powder, in air inlet duct of Air Preheater and as near as possible to Air Preheater. A nozzle with ball valve assembly was welded in this hole. A metallic pot, having a capacity of holding approximately 2.0 kg powder, was placed on top of this valve. Pot was filled with in-house developed fluorescent powder. The valve was opened and let powder settled in air inlet duct. Valve closed and FD Fan started to flow the heaped powder in air path for approximately 45 ~ 60 seconds. Powder passed from air path to flue gas path through leaky element of Air Preheater modules. Inspection using ultraviolet light was carried out on flue gas path side of the module. The leaky elements were identified using ultraviolet light instantly.

Photo-1: Top of flue gas outlet side of one of the modules.

Photo-2: Photo after partial repair of few elements

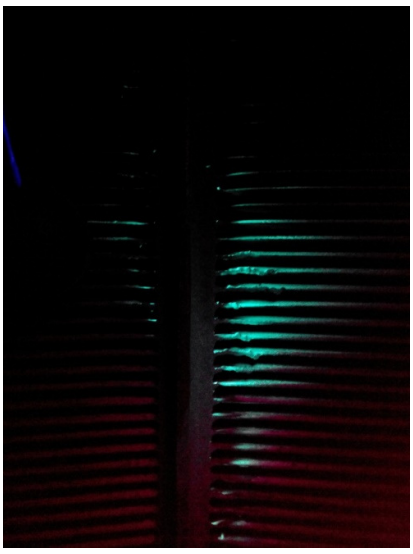

Photo-3: Photo in ultraviolet light shows leaky elements of same module.

Inspection using ultraviolet light was carried out from both flue gas inlet and outlet side of Air Preheater. Leakages were identified in all modules in flue gas inlet and outlet side. However, number of leaky elements on flue gas outlet side was less as compared to flue gas inlet side.

Close visual inspection of leaky elements revealed that seal welding of elements was opened up. Few plates of the element were found torn out from its seal weld. The maximum length of torn out plate was @ 125 mm and it had gone to a maximum depth of @ 20 mm.

4. Repair of leaky plates:

Repairing was carried out in damaged elements of modules on flue gas side. MOC of Plates is SS304 and thickness is about 1.2mm. Mechanical Workshop had carried out precise cleaning using special types of wire/power brush before welding to removehard dust/deposits from the surface. Repair welding was carried out using 1.2 mm size filler wire of ER-308 using GTAW technique.

5. Result:

After repairing of elements, Air Preheater was taken in operation. Again simulation and back calculations were carried out after stabilization of plant. The report clearly indicated reduction in leaked air flow from 2600 NM^3/Hrto 500NM^3/Hr.

SGGU FG CALCULATION FOR 26-04-2014

Remark

1 Calculations are based on point readings of 26-04-2014
2 Air flow and leakage air are back calculated based on O2 analyzer and lab analysis
3 Air flow and hence FG flow and composition will depend on accuracy of O2 analyzers
4 Online indicators are taken as wet basis where as lab results are dry basis
5 CA air indicated is @ 39210 Nm3/hr which seems to be on lower side when compared with simulated data for matching reformer box Temp/O2 profile
6 Corrected flow of fuel NG and PG fuel taken.

Calculated Resuts

NG Fuel (MW corrected)-		NM3/hr	2648
PG fuel (MW corrected)-		NM3/hr	2680
CA flow to match box Temp/O2 profile		NM3/hr	42500
Leak air flow to match Lab O2		NM3/hr	500
Flue Gas Flow		kg/hr	56795
FG Analysis (Wet)		mol%	Wet
	O2		2.5
	CO2		7.2
	N2		69.3
	H2O		21

6. Acknowledgement:

We would like to thank management of Gujarat Narmada Valley Fertilizers Co. Ltd. for permitting us, and Non Destructive Evaluation–2015 committee for giving us an opportunity to share our experience of successfulapplication of innovative and in-house developed ultraviolet light test method in this seminar.