

Coating in Primary Reformer's Radiant Section

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Abstract

Kaltim Parna Industri, (KPI), experienced severe fouling on the flue gas side of the coil heat exchangers. This happened on the outer tube side, which some were finned tubes. Although the cause had not clearly been identified, laboratory analysis indicated that the fouling had similar composition with the firebrick. Therefore, preliminary assumption of what causes the problem was firebrick erosion that was carried away by flue gas flow.

In order to completely eliminate fouling source and hopefully to reduce cleaning frequency, we planned to coat combustion chamber with special high temperature resistance coating. The result was promising that the material was stable against high temperature and even further helped the operation.

Keywords: convection section, fouling, coating, firebrick, reformer

Abstrak

Kaltim Parna Industri (KPI) mengalami masalah pada *coil heat exchanger* pada bagian konveksi *primary reformer* yang memanfaatkan panas *flue gas* yaitu berupa *fouling* pada bagian luar *tube coil exchanger* (*finned tube*). Pada awalnya belum diketahui sumber penyebab *fouling*, namun dari hasil analisis laboratorium diketahui bahwa komponen penyusun *fouling* sama dengan komponen *firebrick* (batu tahan api). Oleh karena itu diambil kesimpulan bahwa penyebab *fouling* adalah *firebrick* yang tererosi lalu terbawa aliran *flue gas*.

Salah satu cara untuk menghilangkan sumber *fouling* adalah dengan melakukan *coating* pada ruang bakar yang terdapat *firebrick* di dalamnya. *Coating* dilakukan dengan menggunakan cat khusus yang tahan suhu tinggi yang mampu menahan permukaan *fire brick* dari erosi.

Kata kunci: seksi konveksi, *fouling*, pelapisan, *firebrick*, reformer

Introduction

PT. Kaltim Parna Industri, well-known as KPI, founded on February 13, 1996, has been known as one of leading manufacturer and exporter of ammonia in Asia and Australia. The ammonia plant is designed to produce Anhydrous Ammonia with capacity of 1,500 MT/day along with all supporting utilities. Our vision "To be the most efficient ammonia producer in the world", embraces High Productivity, Efficiency in Energy, Satisfactory of Market and QSHE (Quality, Safety, Health & Environment).

In KPI, plant reforming process consists of two reformers; Primary and Secondary reformers. The primary reformer is divided into two sections: radiant and convection section. Radiant section is located in lower part of the furnace where the burners and catalyst tubes are located. Convection section is located in the upper side adjacent to the radiant section.

KPI's Primary Reformer is a duplex chamber reformer (having two parallel furnaces) with a

Table 1. Convection section coil heat exchanger

Heat Exchangers	Gas Process Stream	Total Area, m ²	Remarks
E-0201	Reformer's feed gas	348.96	Bare. 1 bundle
E-0202A	Process Air	182.32	Bare. 1 bundle
E-0203-1	Steam	679.00	Bare. 2 bundles
E-0203-2	Steam	4,152.96	Finned. 1 bundle
E-0204A	Natural Gas	478.40	Finned. 1 bundle
E-0202B	Process air	599.86	Finned. 1 bundle
E-0204B	Natural Gas	897.93	Finned. 1 bundle
E-0205	BFW	8,056.27	Finned. 4 bundles
E-0204C	Natural Gas	801.07	Finned. 1 bundle
TOTAL		16,196.76	

single flue gas duct, designed by Haldor Topsoe. The reformer has two inlet distributors and single cold collector or transfer line, which is connected to catalyst tubes by a number of hot sub-collectors and pigtailed. Combustion air is introduced to the burner using two induce draft fans located at the top of flue gas duct that also keeps furnace chamber in vacuum. In the convection section, heat from flue gas is used to heat process gas streams.

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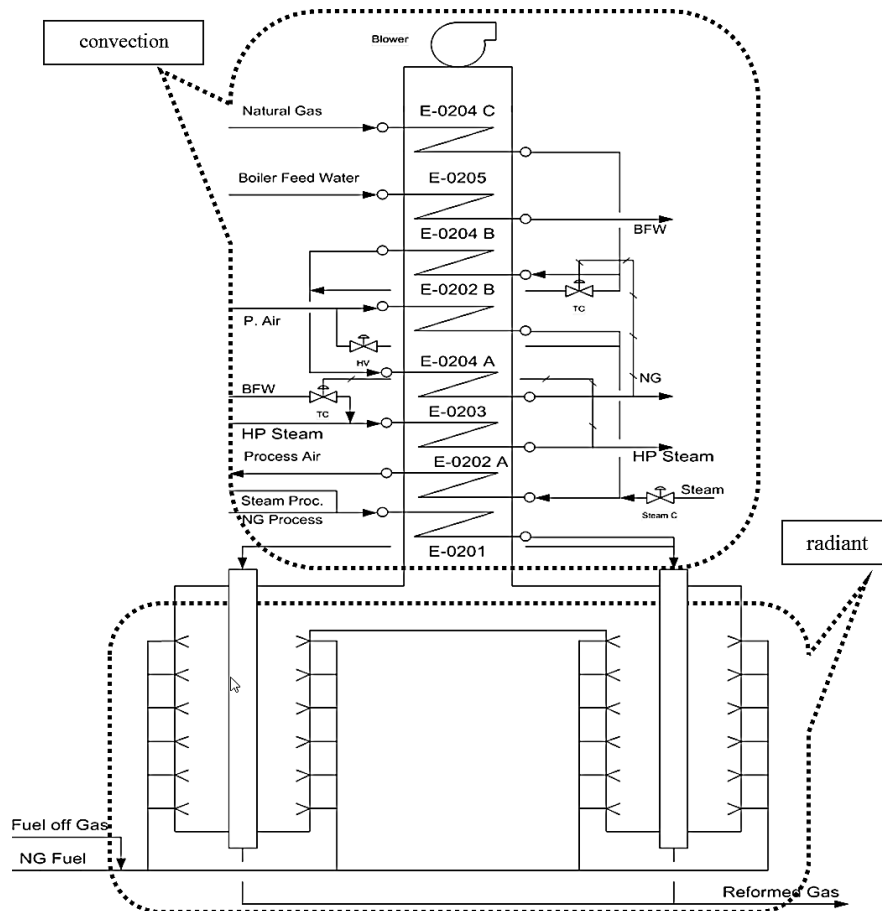


Figure 1. Primary reformer (radiant and convection section)

Table 2. Fouling composition

Parameters	Units	Refractory (reference)	Fouling	Methods
Appearance	-	Brown powder	Brown dust	-
Total insoluble matter	% weight	79.64	67.11	Gravimetric
Fe (Iron)	% weight	0.10	5.19	AAS
Cr (Chromium)	% weight	0.16	0.22	AAS
Ca (Calcium)	% weight	1.90	0.77	AAS
Cu (Copper)	% weight	Trace	Trace	AAS
Ni (Nickel)	% weight	Trace	Trace	AAS
Loss on ignition	% weight	0.30	0.85	Gravimetric

During process turn around, there was opportunity to inspect the convection section and it was found that exchanger's coils were severely fouled by red-colored material. Physical appearance indicated that the material was similar to the refractory (radiant wall), which was further confirmed by laboratory analysis.

From this evidence, we concluded that there was evaporation or erosion of refractory material in the radiant chamber. Initial assumption was that the fouling contamination would stop by itself after saturated by the refractory. However, after several cleaning works, we observed that there was no decreasing tendency and therefore

we decided to prevent the source of fouling by coating the firebrick inside radiant section in order to reduce erosion caused by flue gas.

Methodology

Convection Section Cleaning

Before coating radiant section was conducted, we had to clean convection section in order to eliminate fouling film attached on coil exchangers. Cleaning was carried out by sandblasting using garnet sand since refractory material is sensitive to water (wet cleaning method). Garnet 20/40 mesh (425 – 850 microns)

was chosen due to the following advantages compared to silica:

- High hardness (7.5 - 8 MOHS), not easily break-up and avoiding the convection section dirty.
- High melting point (min. 1,350 °C). It is beneficial in case of some left over, it will not add more troubles as operation temperature at the inlet of convection section is about 950°C.
- Higher specific gravity (SG) of the abrasive grain and low breakdown rate, also resulting in reduced dust level, thus ensuring good operator visibility. Higher SG also means less power required to achieve similar result with silica.
- Having minimal ferrous particles, which will reduce risk of ferrous contamination to the surface.
- Faster cleaning speed, due to low power requirement (Sukardi and Supriyadi, 2007).

Radiant Section (Combustion Chamber) Coating

Coating thickness was applied differently, ranging from 1 mm to very thick, to confirm theoretical coverage area of 3 kg/m² using our chosen furnace coating “Furnascote Novit”. This material was characterized by very high content of zirconia and imparts high resistance to aggressive attacking environments typically encountered at high temperature. Complete chemical composition is as follow: zirconium 62.97%, aluminum 1.63%, calcium 1.37%, magnesium 0.34%, silicon 32.06%, titanium 0.25%, boron 1.1% and fluorine 0.25%.



Figure 2. Scaffolding installation

A mixture of furnascote in water (25 kg of furnascote in 3.2 Liters water) was applied using a paintbrush. Required quantity was about 2 – 3 kg/m² in order to achieve a thickness of 1 – 2 mm (arbitrary). It had a good adhesion to the

refractory wall. Then, the sample was aerated several days for natural drying, in order to avoid thermal shock and rapid evaporation upon burner ignition.

The procedure of coating were described as below :

1. Coating material preparation. This step was conducted by our vendor.
2. Scaffolding installation. We hired a subcontractor, local based, to install scaffolding inside radiant section.
3. Brushing reformer tube and surface preparation. In order to eliminate dust particles attached at tube and radiant wall, we brushed them so the result of coating would be satisfied.



Figure 3. Brushing reformer tube and re-fractory surface hand brushing

4. Coating application. The mixture of furnacecote was spreaded all over radiant section wall.



Figure 4. Application of coating

Results and Discussion

After 9 month operation, we had the opportunity to have visual observation during turn around. Results of the observation were as follow:

1. Visually, the coating material strongly attached to the castable surface. Only minor

deterioration occurred. Further investigation showed that the coating was thicker than the others. Therefore, it was concluded that excessive thickness was not preferable.

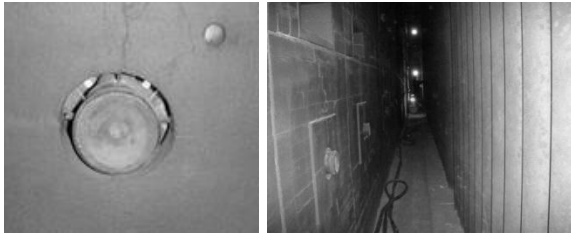


Figure 5. After coating (cold condition)

- Coated surface was smoother than non-coated surface, which is in line with observation during operation. This surface was shinier, which indicated better reflections. Inspection through peephole indicated that radiant wall illuminated brighter than before. It could be said that the radiation heat transfer increased. (Beacon, 2009)



Figure 6. Radiant wall in hot condition before coating (left) and after coating (right).

Red fouling can be removed even from the hardest positions inside the tube bank.

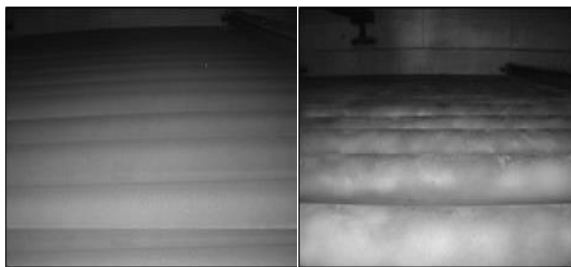


Figure 7. Coil exchangers condition before cleaning (left) and after cleaning (right).

Evaluation was conducted regarding to the consumption of fuel by comparing before and after coating. After coating we used less amount of fuel to produce ammonia. Compared to that before coating, the difference was about 0.209 MMBTU/MT NH_3 . Refractory of radiant wall was able to absorb more heat rather than to

release the heat to the flue gas because of the high emissivity of the radiant wall after coating.

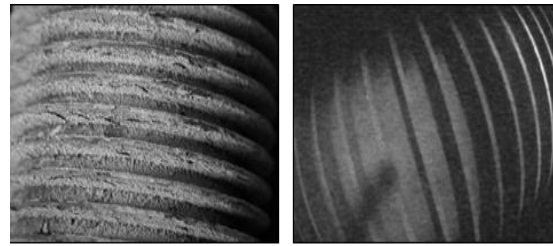


Figure 8. Finned coil exchangers condition before cleaning (left) and after cleaning (right).

Based on the visual inspection and evaluation, it could be concluded that coating on the radiant section wall deliver satisfying results. After plant operation for almost one year, the coating remains in a good condition without any damage. In other word, the coating has a good durability toward heat so that annual coating may not be needed.

Table 3. Comparison of fuel consumption before-after coating with NH_3 production 1,555 MTPD (basis).

	Unit	Before coating	After coating
Fuel Flow	Nm^3/hr	15.97	15.91
	MMscf/hr	657.8	657.3
GHV	$\text{MMBTU}/\text{MMscf}$	1,103.9	1,107.2
Fuel consumption to produce 1 ton NH_3	MMBTU/MT	12.10	11.89

Conclusion

Coating Radiant Section in Primary Reformer gives some benefits to KPI on exchanger tubes:

- The fouling material is suspected from the refractory by erosion/evaporation, which enhance the heat reflection of primary reformer wall to the catalyst tube.
- Excessive thickness of coating is not preferable since coating thickness of 1 mm could strongly adhere to the castable surface.
- We used to clean convection section once a year during turn around. After coating radiant section applied, the frequency of convection section cleaning can be reduced.
- Energy saving due to less fuel consumption to produce the same amount of ammonia product.

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