ODOUR REDUCTION ON ALUMINA REFINERY

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Abstract

Objective:
To reduce odour levels from Oxalate Kiln at Alcoa's Pinjarra alumina refinery.

Statement of Findings:
The raw bauxite feed stock in Western Australia is unique and contains soil based impurities that when processed release some odours from the refinery. This was particularly the case at the discharge of the Oxalate Kiln at Pinjarra refinery. The odours were tested and found to contain compounds that could be oxidised to reduce the odour levels.

The technology chosen to reduce odour is a Regenerative Thermal Oxidiser (RTO). An RTO uses patented honeycomb ceramics to achieve the heat regeneration and thus reducing the operating costs dramatically when compared to a standard Thermal Oxidiser.

A major challenge in the application was the presence of caustic compounds in the raw gas and the effect of this on the ceramics, which are predominantly manufactured from an Aluminium base.

Key Conclusions:
By utilising the best available technology to oxidise these compounds, the odour levels have been reduced by approximately 99%.

The life of the ceramics was greatly increased following the development of a caustic resistant ceramic, which utilises more rare minerals to provide the necessary heat exchange.

The technology has also been successfully applied to other applications on Alcoa refineries, namely liquor burning kiln emissions and for destruction of digestion odours.

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1. Introduction

The primary focus of the project was to provide a reduction of the odour levels that were prevalent at Alcoa's Pinjarra alumina refinery. The source of these odours was as a result of soil based impurities in the raw bauxite feed stock, that when processed release some odours from the refinery. Whilst these particular impurities are unique to the bauxite feed stock in Western Australia, there are probably similar organics found in other sources of bauxite. These could produce a similar suite of odour compounds if subjected to the Bayer process and burned in an oxalate kiln.

The focus of this paper is the Oxalate Kiln at the Pinjarra refinery.

2. Investigation and Findings

At the start of the project a raft of tests were conducted by Alcoa to determine what the odour was that was emanating from the Oxalate Kiln. The testing was carried out in accordance with USEPA methods, or those that have been NATA approved versions.

The major odorous compounds that have been consistently detected are Acetone; Acetaldehyde; Methyl Ethyl Ketone; Benzene and Toluene. Of these Acetaldehyde makes up virtually the entire odour from these five compounds.

Alcoa conducted tests on the odours from the refinery and found compounds that could be destroyed when subjected to oxidation at high temperatures, between 850C and 1,000C, thus reducing the odours. This led Alcoa to determine the "best available control technology" to provide odour destruction.

Possible technologies that could be used are:

- Thermal Oxidiser (TO), which uses a combustion chamber with gas burner to heat the raw gases up to the desired destruction temperature. The energy use is high due to the fact that the system requires the temperature to rise from the design temperature of 35°C to the destruction temperature of 850°C.
- Recuperative Thermal Oxidiser (RCO), which is similar in concept to the Thermal Oxidiser, but takes the waste heat from the exhaust duct and converts the energy into pre-heating if required for the system, or to generate steam or other forms of energy. The energy used for the destruction is the same; however using the waste heat, makes it more economically viable.
- Regenerative Thermal Oxidiser (RTO), which has a similar combustion chamber arrangement to both units noted above, but has the added sections of ceramic media on the unit's inlet and outlet to capture the heat generated from the combustion chamber to start the heating process of the raw gas for the next cycle. The ceramic is efficient enough that the temperature rise from inlet to outlet is between 25°C to 30°C which is the energy usage figure for the burner. The other major point of difference is the outlet gas is now much cooler and easier to deal with in relation to construction materials for the stack, etc.

Alcoa chose the Regenerative Thermal Oxidiser (RTO) option for the Oxalate Kiln at Pinjarra.

The tables below, using data provided by Alcoa World Alumina, details the levels of these major contaminants as well as the destruction efficiency of the RTO unit.

Sampling Day		1	2	3	4	5	6	7	8	Average	Theoretical Average Odour
	Odour Thresholds	RTO Inlet Concentrations (mg/m^3)									
Acetone	13	2.9	7.05	8.2	3.75	5.6	6.45	5.45	43	10.30	1
Acetaldehyde	0.0019	1.25	3.75	2.65	1.41	1.55	5.95	6.2	24	5.85	3076
Methyl Ethyl Ketone	2	0	1.35	1	0.54	0.54	1.3	0.97	7.85	1.69	1
Method Detection Limit		*0.26*	*0.39*	*0.38*	*0.41*	*0.39*	*0.38*	*0.36*	*0.36*		

Inlet data collected using ECS Method 6

Sampling Day		1	2	3	4	5	6	7	8	Average	Theoretical Average Odour	VOC Destruction Efficiency
	Odour Thresholds	RTO Inlet Concentrations (mg/m^3)										
Acetone	13	1.23	0.52	0.83	1.03	0.31	0	0	1.2	0.64	0	94%
Acetaldehyde	0.0019	0	0	0	0	0	0	0	0	0.00	0	100%
Methyl Ethyl Ketone	2	0	0	0	0	0	0	0	0	0.00	0	100%
Method Detection Limit		*0.36*	*0.38*	*0.37*	*0.38*	*0.38*	*0.37*	*0.32*	*0.36*			

Outlet data collected using ECS Method 6

Sampling Day		1	2	Average	Theoretical Average Odour
	Odour Thresholds	RTO Inlet Concentrations (mg/m^3)			
Benzene	39	0.34	0.71	0.525	0.01
Toluene	9.5	0	0.36	0.180	0.02
Methyl Ethyl Ketone	2	0.23	0.82	0.525	0.26
Method Detection Limit		*0.22*	*0.24*		

Inlet data collected using USEPA Method 18

		RTO Outlet Concentrations (mg/m^3)				VOC Destruction Efficiency
Benzene	39	0.01	0.02	0.015	0.00	97%
Toluene	9.5	0	0.01	0.005	0.00	97%
Methyl Ethyl Ketone	2	0	0	0	0.00	100%
Method Detection Limit		*0.0065*	*0.0073*			

Outlet data collected using USEPA Method 18

As can be seen from the above data, the RTO unit is completely destroying the main odorous compound being Acetaldehyde.

Whilst the other odours with lower concentrations are also being destroyed within the guidelines of the RTO operation.

The investigations then turned to the ceramic media to be used for the application as these are made from a base material using Alumina Oxide. The expected problem was the reaction at high temperature with varying amounts of caustic (NaOH) present in the raw gas due to the existing wet scrubber upstream of the proposed RTO unit. During these trials it was determined that the standard ceramics would break down in the top layer and need replacement, the length of operation was indeterminate.

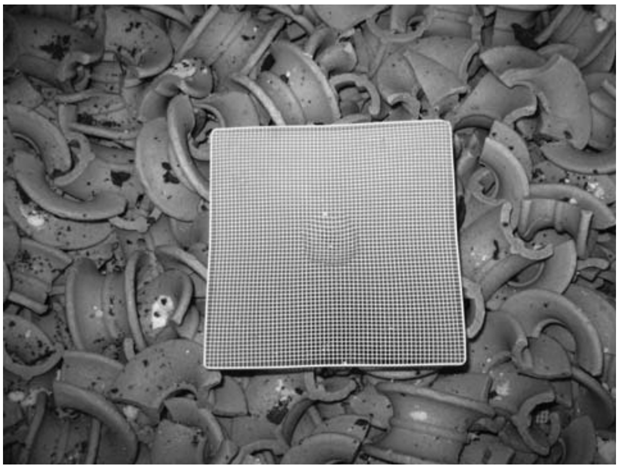
RTO Unit during construction

The three bed RTO unit was installed during 2004 and, following successful commissioning, the unit operated without incident for approximately 4 months. The test results of the contaminants and the odours from the exhaust stack proved the technology and improved the conditions on site. The pressure drop across the RTO was monitored and after 4 months the pressure increase indicated that the blocks were in fact starting to breakdown. They were subsequently removed and replaced, with the RTO going back into operation.

Ceramic Blocks during installation

Damaged top layer of ceramics after 4 months operation

Our technology partner from Austria – Chemisch Thermische Prozesstechnick (CTP) – had started developing a more caustic resistant material for the top layer of the RTO unit prior to this stoppage. This research and development by CTP led to the development of a ceramic using rare earths and rare metal substrates to not only enable the similar thermal properties of the ceramic to be retained, but also provide a longer operational time. This block has a code number CR20.



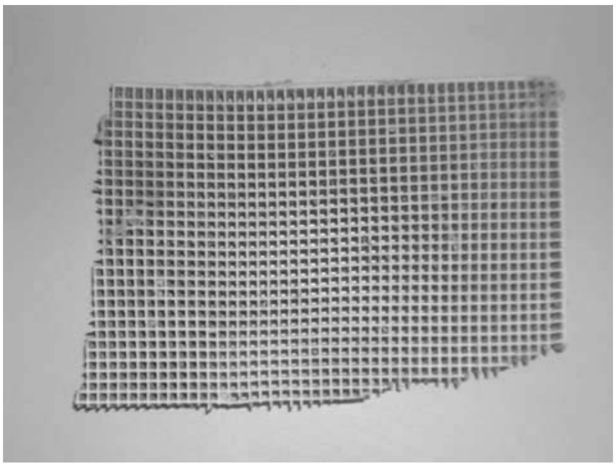
Sample of CR20 placed in RTO for testing

One of the obvious down sides of this ceramic was the cost penalty of the materials used, however the additional operating time of these blocks when they were initially installed in 2006 was justification.

The table below provides an insight into the timeline of the ceramic block change outs for the Oxalate Kiln RTO unit:

Description of works	Time frame
RTO unit commissioned	February 2005
Sample of CR20 installed (after top layer replaced)	September 2005
Sample removed for testing	February 2006
First installation of CR20 ceramics	June 2006
Top layer of CR20 replaced	November 2008
Top layer of CR20 replaced	June 2011

As can be seen from the above table, there has been a trend of increasing time between the unit shutdowns to replace ceramic blocks.



Part of sample CR20 ceramic after 6 months operation

As a result of the reducing supply and increasing demand for these rare minerals, the cost to produce these ceramic elements is becoming prohibitive. As a result, following the latest order for the ceramic block replacements, CTP have developed a number of alternative materials to use in place of the previous CR20 blocks. Samples of these materials are to be installed in the Pinjarra Oxalate Kiln RTO in the next planned shutdown of the RTO unit with the result to be known after 12 months in operation.

3. Conclusions

The RTO technology has proven to be the best available control technology for this application and has since been installed on Alcoa sites in Western Australia. These include the following systems:

Pinjarra – Digestion unit:	destroying odours collected from around the digestion area.
Kwinana – Liquor Burning unit:	destroying odours from the outlet of the Liquor Burning kiln.
Wagerup – Oxalate Kiln unit:	destroying odours from the outlet of the Oxalate kiln.
Wagerup – Liquor Burning unit:	destroying odours from the outlet of the Liquor Burning kiln.

The most important aspect of the project has been that odour levels on the sites have been reduced in line with strict environmental guidelines.

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