Removal Of Moisture From Off Gas Containing NO_X And SO_X

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Abstract- The drying operation in the process in the Zirconium Oxide Plant at Nuclear Fuel Complex, Hyderabad, reduces the moisture content of the wet cake from 70% to ~1%. Volatiles like ammonium nitrate & sulfate also get removed. In the Drying operation of ZOP at NFC, wet zirconium hydroxide cake containing around 75% moisture is dried in static bed to remove all the moisture. Drying the 18 hr batch operation, around 450kg/hr of water vapor is generated and releases through a 40 m stack after scrubbing of pollutants like NO_X & SO_X. Due to this moisture, white fumes coming out of the stack is one of the problem according to the public perception. To remove this moisture a condenser is designed by following the pilot plant observation.

Index Terms- Moisture Removal, Condensation, Plum Opacity.

1. INTRODUCTION

The production of nuclear pure Zirconium oxide constitutes an essential intermediate step in the extraction of Zirconium metal from the ore. The removal of Hafnium which has a high absorption cross-section for thermal neutrons and which is present in zircon (starting material for Zirconium extraction) to the extent of about 2.5% of its zirconium content, therefore, assumes special significance in the production of nuclear grade zirconium oxide.

The drying operation in the process in the Zirconium Oxide Plant at Nuclear Fuel Complex, Hyderabad, reduces the moisture content of the wet cake from 70% to ~1%. Volatiles like ammonium nitrate & sulfate also get removed. The drying operation is carried out continuously at 230°C in a series of box-type High temperature ovens (HTOs). The exhaust from the HTOs is scrubbed with water & carries large amounts of moisture, which further get carried to the stack.

Due to this moisture, white fumes i.e. plume coming out of the stack. Plume from a cooling tower can pose a several issues. It may affect visibility and safety as well as public perception. Plume abatement is the process of removing this visible plume. It seems as a major problem according to the public perception.

Therefore it is necessary to reduce / remove the plume exhausting from the stack.

2. Methods

There are several methods which can be used to remove the plume coming out of the stack. Some of the best methods are as follows:

2.1 Condensation

Adding a condenser before stack is one of the best solution for the particular problem. Because of this, gas containing NO_X & SO_X can become moisture free and problem can be solved.

2.2. Heating the Gas

In this process, if we increase the temperature of the off gas before it goes to the stack, so that it will not get condensed inside the stack. Hot gas can go out because of its high temperature without condensing. But, problem with this method may occur i.e. due to high temperature, pressure will also get increased which will affect the stack. Also, in this method, due to high temperature, material of construction will also get affected.

2.3. Stack Height

As we increase the stack height, the plume coming out of the stack gets expanded due to low atmospheric pressure and therefore it will not be visible. But AERB (Atomic Energy Regulatory Board) have some standards for every equipment's specifications. According to that standard, we cannot increase the height of the particular stack present in ZOP.

From the methods discussed above, plume reduction by the condensation method is studied in this review.

3. Pilot Plant Test

An experiment has done by putting a pilot plant to test whether condensation method will work for the particular plant.

3.1 Observation

Out of total gas flow rate of 22500 kg/hr, 130 kg/hr of gas is passed through the chiller available and the amount of condensate is collected. After 1 hr the condensate collected was 3.55 kg.

On this basis, total mass of condensate is calculated. The condenser is designed assuming 75% efficiency.

Gas flow rate	= 22500 kg/hr
Through put	= 130 kg/hr
Condensate collected	= 3.55 kg water in 1 hr

Therefore,

Total mass flow rate of condensate
= [(22500*3.55)/130]*0.75
= 460 Kg/hr

By using this mass flow rate of condensate, a shell and tube condenser is designed. The data considered for the same is as follows :

Mass flow rate of Air	= 22000 kg/hr
Inlet temperature of Air	= 55 ºC
Outlet temperature of Air	=26 ºC
Mass flow rate of condensate	= 450 kg/hr
Inlet temperature of Water	= 34 ºC
Outlet temperature of Water	= 25 ºC

Enthalpy of Air-Water at given temperature = 29.075kj.kg

4. Result & Discussions

The mass flow rate collected (460kg/hr) from the experiment is almost same as the theoretical data.
According to above considerations, the specifications for the condenser designed are as follows:

Identification : Item Condenser
Number required : 1
Function : Condense Vapor
Operation : Continuous
Type : 2-4 Horizontal Condenser
Shell side condensation

Shell Side
Fluid handled : Air
Density : 1.2 kg/m^3
Viscosity : 0.01mNs/ m^2
Thermal conductivity : 0.0271 w/m.ºC
Specific heat Cp : 1.005 kj/kg
Flow Rate : 22000Kg/hr
Pressure : 14.7 psi
Temperature : 55ºC-26ºC
Shell : 39 in.
No. of passes : 4
Baffle spacing : 3.5 in.

Tube Side
Fluid handled : Cold Water
Density : 993 kg/m^3
Viscosity : 0.8mNs/ m^2
Thermal conductivity : 0.58 w/m.ºC
Specific heat Cp : 4.2 kj/kg
Flow Rate : 4.70 kg/sec
Pressure : 14.7 psi
Temperature : 25 ºC-34 ºC
Tubes : 0.75 in. Dia
No. of Tubes : 120
Length : 16 ft
No. of passes : 4
23.8 triangular pitch

Utilities : Water
$U_{Assumed}$: 1000 w/m^2.ºC
$U_{Calculated}$: 907w/m^2.ºC

5. Conclusion

From pilot plant studies, we found that the amount of liquid condensed is equal to that of liquid entering into the HTOs which causes formation of the plume. By considering pilot plant results, a design of condenser is suggested for the particular plant. This design of condenser can remove / reduce the plume coming out from the stack and also can fulfill the standards of Atomic Energy Regulatory Board.

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