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SO_3 FLOW BIASING, AN ENGINEERED APPROACH

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One of the major problems that have been encountered in the attempts to perform SO_3 conditioning of multiple ESP (electrostatic precipitator) path units is the distribution of SO_3 gas to the path where it is needed in the correct quantities. In cases where a Lungstrum type rotating air heater is used, where environmental conditions such as ambient air temperature are affecting duct temperature or when uneven distribution of ash causes an imbalance in loading, how can you deliver the correct amount of SO_3 to the paths in need of additional conditioning without over conditioning the others? Several approaches have been tried such as valves, remote converters or even orifice plates in the SO_3 lines. All of these methods have short comings when trying to adjust flow to the various ESP paths.

INTRODUCTION

SO_3 flow biasing is a process that adjusts the SO_3 flow to various precipitator paths according to a need basis and is adjustable across a wide range of PPM treatment ranges. This is accomplish through the use of hot air that is injected into the piping at temperatures above that of the SO_3 gas dew point in order to minimize the formation of sulfuric acid in the piping and injectors. SO_3 flow biasing is a patented process that adjusts the flow between precipitator paths. (Ref #2)

PROBLEMS ASSOCIATED WITH OVER CONDITIONING WITH SO3

The most common need for flow biasing is in those power plants that have an uneven heat distribution caused by rotating air heaters. Typically, as flue gas temperatures rise, a corresponding rise in the resistivity of the fly ash is also noticed. (see figure 1)

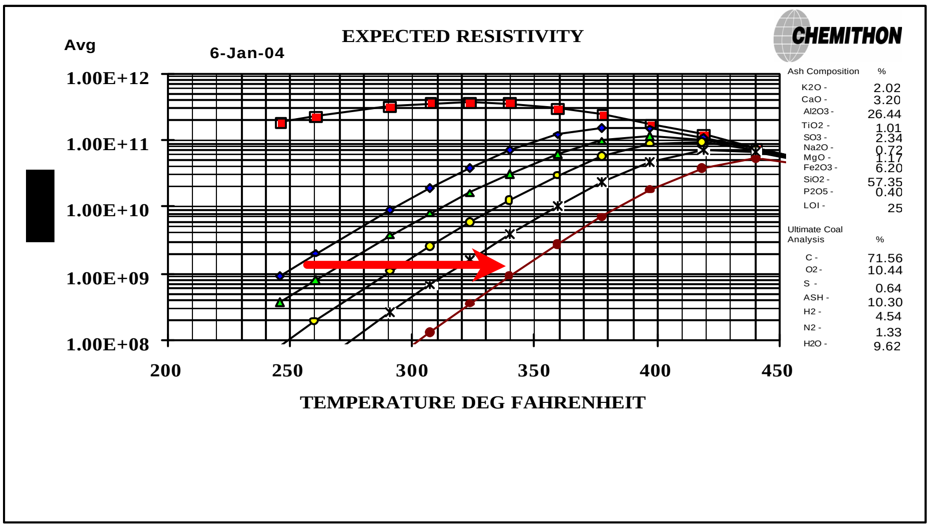

Figure 1 Expected Resistivity of Ash

The graph predicts that as temperatures rise in the duct, a greater treatment rate of SO_3 is required in order to maintain resistivity in the correct range for collection in ESPs.

The increase in SO_3 conditioning levels does help the hotter path by lowering resistivity but causes unwanted over conditioning in the cooler paths. In cases where over conditioning is occurring, the resistivity of the ash is lowered to the point that it becomes overly conductive. This in turn causes a loss of electrical charge through the ash to the collection plates and the ash fails to hang together as a cohesive mass during rapping. This causes problems with re-entrainment of the ash. This is typically evidenced by an increase in rapping spike intensity and frequency and greater average opacity levels.

The other major problem with over conditioning the cooler side is the formation of unwanted acid on the duct work and inlet plates on the ESP. The method in which SO_3 conditions the ash is to form H_2SO_4 (sulfuric acid) on the ash particle. The SO_3 is made available both as a result of the sulfur contained in the coal and through the injection of SO_3 into the flue gas stream and the mixing of the SO_3 with available moisture in the flue gas stream. (see figure 2)

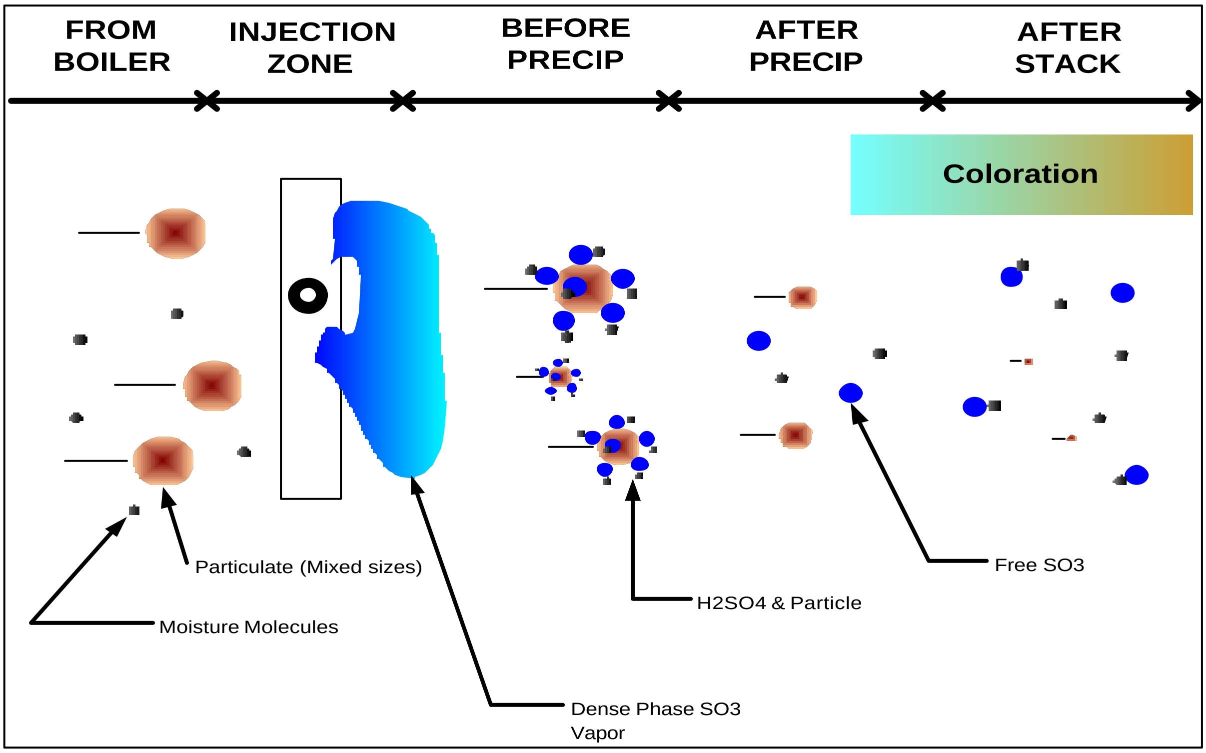

Figure 2 Free SO3 in Gas Stream

As free SO_3 moves along its path, it will find additional moisture molecules to support the formation of additional sulfuric acid which then condenses on the steel duct work and internal ESP steel. This unwanted condensation of sulfuric acid causes both the corrosion of steel parts and lead to the collection of unwanted ash on the distribution plates, electrodes and collection plates. See figure 3 and 4.

Figure 3 Blocked Distribution Plates

		B- Side				A- Side		
	Rows	Outlet Trail	Inlet Trailing		Rows	Inlet Trailin	Outlet Trailing	
	55	0.0301	0.0203		5	0.0256	0.0276	
	45	0.0309	0.0203		15	0.0208	0.0257	
	35	0.0303	0.0218		25	0.0212	0.0275	
	25	0.0309	0.0211		35	0.0184	0.0276	
	15	0.0302	0.0219		45	0.0256	0.0266	
Cell 4	5	0.0317	0.0218		55	0.0212	0.0287	Cell 1
	55	0.0287	0.0221		5	0.0241	0.0282	
	45	0.0294	0.0219		15	0.021	0.0288	
	35	0.0322	0.0234		25	0.023	0.0293	
	25	0.0323	0.0263		35	0.0222	0.029	
	15	0.0322	0.0223		45	0.0265	0.0296	
Cell 3	5	0.0335	0.026		55	0.0258	0.0303	Cell 2
	55	0.0343	0.0254		5	0.0244	0.0311	
	45	0.0331	0.0266		15	0.0229	0.0311	
	35	0.0331	0.0273		25	0.0243	0.0313	
	25	0.033	0.0293		35	0.0247	0.0322	
	15	0.032	0.0314		45	0.0253	0.031	
Cell 2	5	0.0327	0.0298		55	0.0265	0.032	Cell 3
	55	0.0332	0.0292		5	0.0277	0.0333	
	45	0.0322	0.0302		15	0.0277	0.0313	
	35	0.0334	0.0303		25	0.0298	0.0326	
	25	0.0319	0.03		35	0.0286	0.0319	
	15	0.0325	0.0318		45	0.0293	0.0318	
Cell 1	5	0.0325	0.033		55	0.0257	0.0331	Cell 4
	Average	0.0319	0.0260			0.0247	0.0301	
	Average			0.0282				

Figure 4 Evidence of Corrosion

"A" path is the cooler of the two paths and therefore is experiencing the largest amount of corrosion from over conditioning of ash. The sulfuric acid that is not being absorbed onto the ash is collecting on the cooler steel surfaces of the duct work and ESP causing corrosion.

FLOW SPLITTING BY CONVENTIONAL METHODS

The primary problems encountered in attempting flow splitting of SO_3 gas with conventional methods such as valves or orifice plates is that as you slow the flow of SO_3 in the transfer piping. As it cools in the piping and injectors, it once again forms unwanted sulfuric acid. The sulfuric acid that forms, takes away from available treatment, coats the piping with a layer of high corrosive acid and can cause injector fouling and plugging. The problem of sulfuric acid condensation is especially pronounced at valves and flanges in the piping. Any place that excessive cooling has taken place supports the formation of sulfuric acid. Sulfuric acid, once it has condensed in the piping, is very difficult to re-vaporize. Because sulfuric acid remains in the piping, it becomes very aggressive at the high temperatures usually seen in SO_3 piping. (see figure 5)

Figure 5 Acid Formation in Piping

This can cause premature failure of piping, Valves and other components of the SO_3 injection systems.

FLOW BIASING WITH DILUTION AIR

In order to overcome the problem of cooling and acid formation, an alternative method of adjusting the SO_3 treatment rate is needed.

In a typical SO_3 injection grid there are several bifurcations that allow for even distribution of SO_3 gas flow to each of the path(s) and thus to each of the injectors. The method that Chemithon has developed and patented to adjust the SO_3 flow rates between path(s) is to increase or decrease the SO_3 line pressure in a particular path by the use of hot injection air. The increasing of line pressure changes the flow of SO_3 to the path(s) that require additional treatment while at the same time preventing over conditioning of the other path(s).

The system is comprised of an air source that can be secondary or it can use the primary air supply from the gas generator skid, an air heater of sufficient size to heat the required mass of air above the dew point of sulfuric acid along with an assortment of valves and instruments to control both temperature and flow of the biasing air. The important point is that we are controlling air flow which is much friendlier than SO_3 to equipment. Each path of a boiler requires a both an air source and heater to correctly control that path's treatment rate.

The biasing air is heated to above 300 deg C and is then injected into the SO_3 piping after the pipe bifurcates to each path. The process works by increasing the air pressure in a particular path and group of injectors and at the same time decreasing pressure to the other path(s). The increase in air pressure in the piping forces more SO_3 treatment to follow the path of least resistance. At the same time we lower the other path(s) pressure and thus resistance to flow which increase the treat rate in that path or group of injectors. Because additional hot air is being injected into the piping, the sulfuric acid dew point is not reached and the formation of acid is also minimized. The reduction of acid has a second very desirable out come of helping to prevent injector fouling. Injector fouling and poor distribution can also have a detrimental effect on emission as well as add to corrosion problems. (see figure 6)

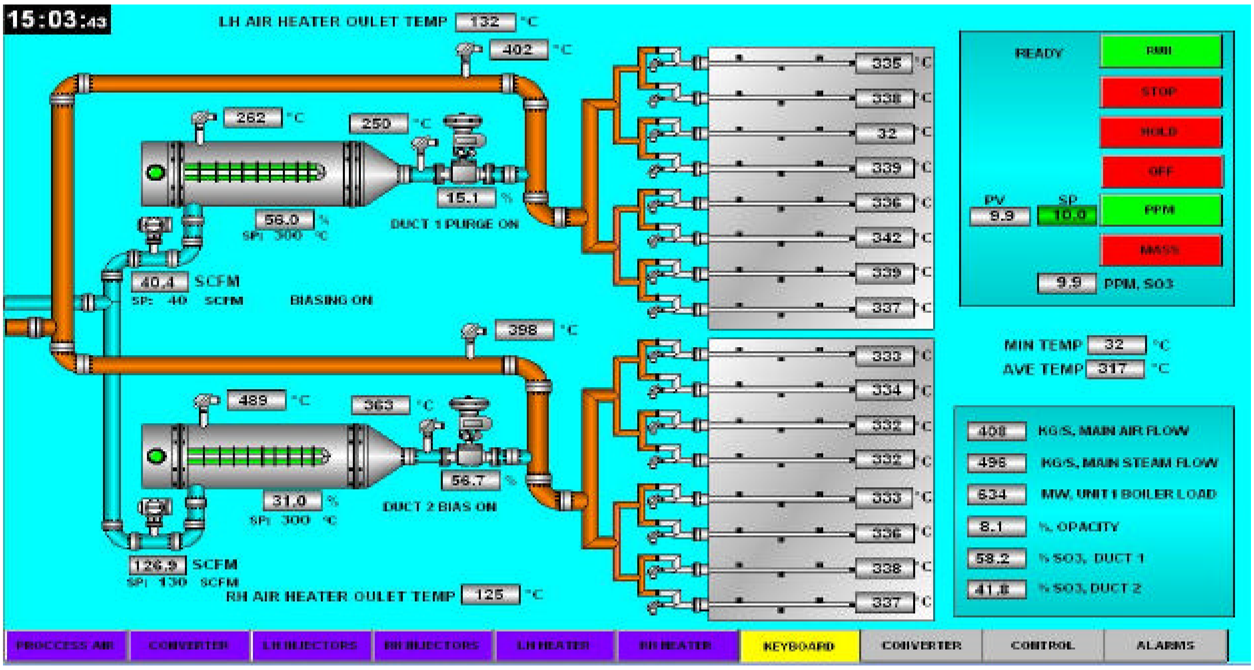

Figure 6 Flow Biasing System

In figure 6, the duct that is being biased is the left hand duct (LH) (upper duct on screen). Note the higher air flow to the right hand (RH) (lower duct on screen) 126 SCFM vs. 40 SCFM This in turn is causing more of the SO_3 to flow to the left hand duct. The reason the duct is being biased is the temperature difference between the two. The LH duct is running about 7 deg C hotter than the RH and is being biased 58 to 41 % as shown in the box at the lower right of the control screen. The opacity is 8.1% combined.

The difference in opacity with a unit using SO_3 with flow biasing can be seen in Figure 7 below where the two sets of data show a unit running first without the use of SO_3 and then with SO_3. The results are quite dramatic. We did not have the ability to look at opacity from each duct individually but these are the results of adjusting flow on the 28th of December to achieve the best possible opacity by biasing the ducts 58 to 41%.

Date	10 MKA80 FE901 XQ01	10 HNA17 CT001 XQ01	10 HNA27 CT001 XQ01	10 HNE01 CE001 XQ01	10 MAG00 FT001 XQ01	10 MAG00 FT001 XQ01
12/28/2005 7:19	ELECTRIC LOAD	RH PRECIP INL T	LH PRECIP INL T	TOT PRECIP DUST EM	AMB AIR T	AMB AIR T
12/29/2005 7:19	MW	CEL	CEL	Dust %	CEL	CEL
12/28/2005 5:11	621.1875	131.1719	139.2578	11.4014	34.6934	34.6934
12/28/2005 5:13	625.7812	131.3438	138.75	10.3271	34.6934	34.6934
12/28/2005 5:15	622.25	131.3438	138.75	12.4692	34.6934	34.6934

Figure 7 with SO_3 and Flow Biasing

Date	10 MKA80 FE901 XQ01	10 HNA17 CT001 XQ01	10 HNA27 CT001 XQ01	10 HNE01 CE001 XQ01	10 MAG00 FT001 XQ01	10 MAG00 FT001 XQ01
12/9/2005 2:25	ELECTRIC LOAD	RH PRECIP INL T	LH PRECIP INL T	TOT PRECIP DUST EM	AMB AIR T	AMB AIR T
12/10/2005 2:25	MW	CEL	CEL	%	CEL	CEL
12/9/2005 5:08	659.8438	125.125	133.8125	37.6816	21.083	21.083
12/9/2005 5:10	661.1562	125.125	133.8125	19.9707	21.0488	21.0488
12/9/2005 5:11	660.0312	125.125	133.8125	19.9707	21.0488	21.0488
12/9/2005 5:13	661.3438	125.125	133.8125	18.8965	21.0488	21.0488
12/9/2005 5:15	660.2812	125.125	133.8125	18.8965	21.0488	21.0488
12/9/2005 5:17	661.3438	125.125	133.8125	25.3223	21.0488	21.0488
12/9/2005 5:19	658.7188	125.125	133.8125	25.3223	21.0488	21.0488
12/9/2005 5:21	660.9375	125.125	134.1328	19.4209	21.0488	21.0488

Figure 7 Continued Without SO_3 Conditioning.

The difference in temperatures of both ambient and duct temperatures between the two show how much of an effect SO_3 conditioning had on this unit. Total dust emissions were cut in half with ambient air temperatures one third higher and duct temperatures 5 to 6 deg C higher. Conditions where you would expect higher emissions due to higher duct temperatures.

OTHER APPLICATIONS FOR FLOW SPLITTING

In application where multiple small boilers such as those at or under100mw are used at a station, flow splitting can be employed as a means to reduce capital costs by flow splitting the SO_3 to two or more boilers from a single SO_3 gas generator.

CONCLUSION

The use of SO_3 flow biasing to treat according to duct temperatures can have a huge impact on both the reduction in emissions and prevent the corrosion of ESP and duct work steel. This use of flow biasing is relatively easy to install and requires very little additional equipment over standard SO_3 equipment. The use of hot air flow biasing prevents the accumulation of harmful acid in process piping and assists in the prevention of injector fouling by having a second source of hot air being injected at the injection grid.

REFERENCES

1. Jerry Klemm, Southern Company Services 2004 SCS Precipitator WorkshopEdgewater Resort, Panama City Fl. 2004
2. United States Patent # 6,895,983