Challenges for old ESP Upgrades at Utility with high Resistive Coal/Ash

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1 Summary / Abstract:

Coal Fired Utility Stations are one of the major users of Electrostatic Precipitators (ESPs) for particulate emission control. These are primarily Pulverised Fuel Fired Boilers with varying Resistivity & Fineness. The paper generally speaks about the challenges that we face with the old Precipitators to cope with stringent emission norms in spite of Physical dimensional and plant layout Restrictions.

The Resistivity & Fineness are two major criteria for Precipitator sizing for Fly Ash. In such conditions, ESPs really face challenges for a lower emission requirement in front of Fabric Filters in spite of quite a few Operation and Maintenance advantages. Today's technology has advanced very fast, particularly in the area of High Frequency Power Supplies in combination with Automatic Semipulse Controls really shows extremely promising results beginning usually at 20 % emission reduction, but commonly much better than this - in spite of all the constraints.

Present scenario for such Utility plants may sometimes not even allow a proper shut-down period to replace/rectify defective Mechanical components or to realign critical ESP internals or to carry out a reasonable Gas Distribution and sneakage Tests. For obvious reason, thrust is more and more towards HV, Electronics and Controls to overcome problems in other areas as a substantial portion of the work can be carried out without a shutdown.

In this paper we discuss and compare the emission performance of an Utility ESP plants in Australia.

2.1 Introduction

Fossil Fuel Fired Utility plants are one of the largest users of the Electrostatic Precipitators. There are wide variations to the Process conditions, thus the Precipitator has to cope with parameter variations, such as extremes of temperature, moisture, particulate burden, Resistivity etc. The combustion process in the boiler together varieties with Coal-ash makes significant difference to the Performance of ESP.

In this part of the world (Australia), generally these Utilities including the precipitators are reasonably old, with increasingly stringent statutory emission regulations, the Precipitators face increasing challenges and quite a few have been converted into Fabric Filters. On top of that, most of these plants are very compact and there is hardly any space to play around with the configuration of the ESPs. The thrust is more and more on ESP Controls to find a better way of optimization and to create a balance between Emission and Power Consumption. Few Utility plants are also very sensitive to emission level as they are located close to residential areas which also creates another pressure.

The use of High Frequency Power Supplies – Alstom's trade name is SIR (Switched Integrated Rectifier) - is becoming a quite common method of improving the efficiency of ESPs in Utility applications, specifically in front zones. SIRs operate at frequencies that are magnitudes higher than line frequency, 23–50 kHz, and thus reduce the ripple voltage down to negligible values.

The rear zones in such situation are equipped with semipulse control system to strive against High Resistivity.

2.2 Case Study

The Utility Power Station at East Coast of Australia has 500 Mw Units, equipped with PF Boiler and each unit is being served by 4 ESP Passes.

In this paper we shall discuss about ESPs for one particular unit. Each ESP pass is having 6 fields in series with varying field length and Collecting Electrode Spacing. First 2 fields are with 2.8 M field length, followed by 3 more fields with 3.6 m field length. All of these 5 fields are having 250 mm Collecting Electrode spacing. A sixth field added later is with 3.75 m field length at 400 mm spacing.

In 1996 Alstom replaced all the existing conventional controllers to the sophisticated Semipulse system (EPIC II).

Eventually SO_3 injection system has also installed to bring the emission further down.

The ESP was designed with the following parameters :

Parameters	Pass A	Pass B	Pass C	Pass D
Flue Gas Flow, m3/s	168	168	168	168
Flue Gas Temperature, Deg C	130	130	130	130
Inlet Dust Conc. g/NM3	25	25	25	25
ESP Efficiency, %	99.28	99.28	99.28	99.28
Outlet Emission, mg/NM3 (worked out)	180	180	180	180

TR Set Rating Field 1 to 5 : 60 KV/800 mA
TR Set Rating Field 6 : 95 KV/800 mA

The last isokinetic sampling result ESP inlet shows the following pattern :

Parameters	Pass A	Pass B	Pass C	Pass D
*Flue Gas Flow, m3/s	252	225	225	265
Flue Gas Temperature, Deg C	151	150	168	168
Inlet Dust Conc. g/NM3	22	22	19	25
Outlet Emission, mg/NM3 (Opacity)	250	240	235	240

* The load was 377 Mw during the test and the data has been extrapolated for 500 Mw.

Coal Analysis (Ultimate)

Name	%
C	82.8
H	5.33
N	2.10
S	0.69
O	9.04

Coal Ash Analysis

Name	As Fired %
SiO2	67.3
Al2O3	26.2
Fe2O3	1.3
CaO	0.33
MgO	0.27
Na2O	0.21

K2O	2.68
TiO2	0.98
Mn3O4	0.02
SO3	0.11
P2O5	0.08
BaO	0.04
SrO	0.02

Further in the beginning of 2010 we have analysed the various data including Electrical Readings both at Air Load and Dust Load, as commented below

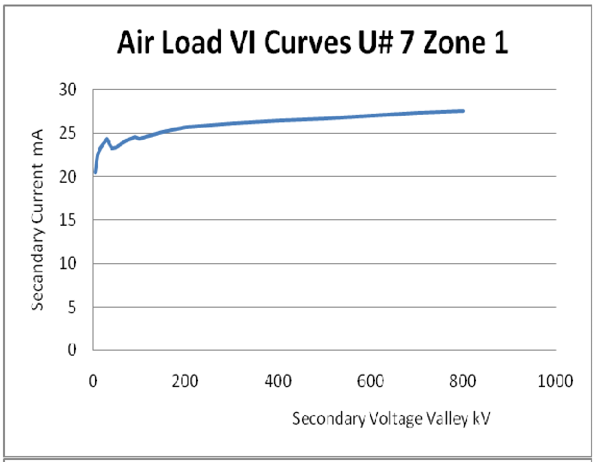
2.2.1 Comments on Air Load Readings

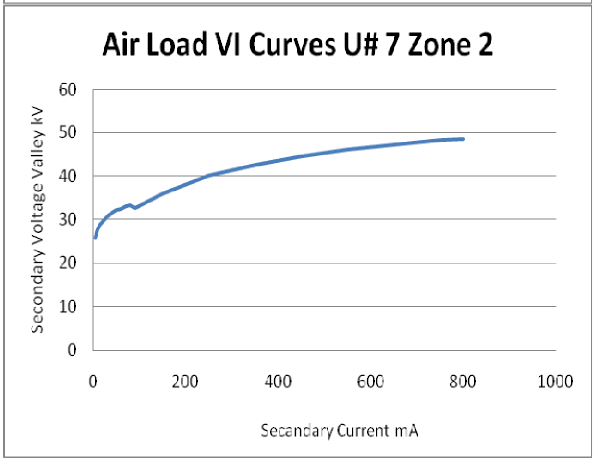
- The voltage values are bit inconsistent in low currents. Typically reliable data for I-V-curves are not available at very low currents as it is required to reach corona onset before getting any current. Though Corona onset will depend on a number of parameter but it could typically be around 20-25 kV. So the conditions are quite unstable in this region and it is better to ignore about point < 10 mA.

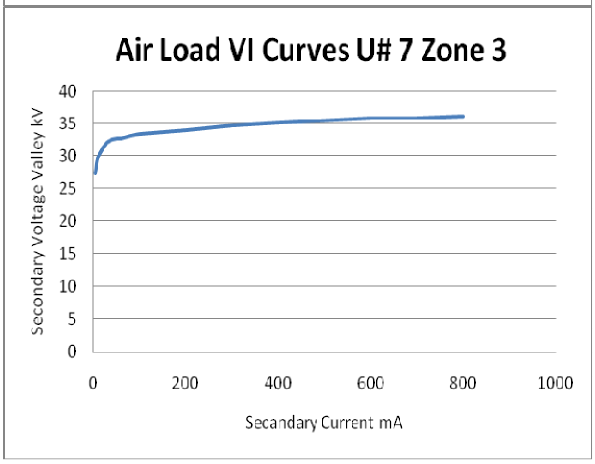
- There are large variations in voltage for the same current densities for the various zones. The sixth field has a larger spacing, so a high voltage is expected but there do not have any obvious reason for the variation between the other zones.

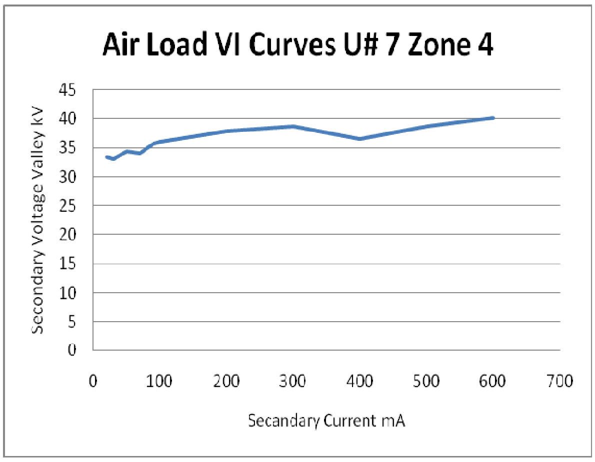
- It is also typical that the voltage increases with increase in gas flow together with the dust load and typically the concentration of fine particles are increasing due to increased space charge. So after boiler start up with increase in boiler load it is likely that an increase in voltage and with time also with increased dust layer thickness.

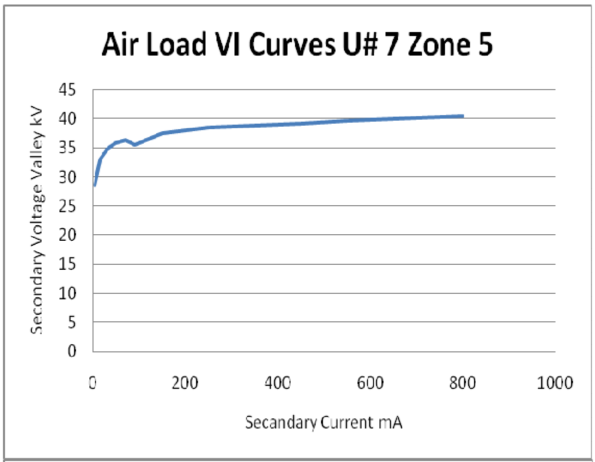
- Please refer to the curves below under figure 2.2-1 for various zones based on the readings received from the Plant.











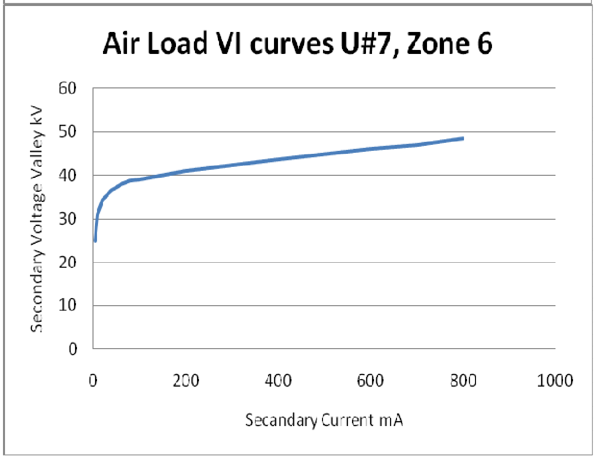


Fig. 2.2-1: Figure Air Load V-I Curve from Zone 1 to 6

2.2.2 Comments on Dust Load Readings

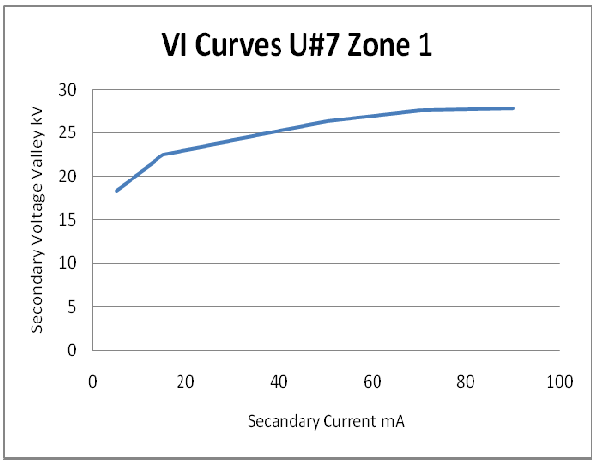
- First two fields are limited by sparking and these fields have low voltage and power input. HFPS are generally better for such situations.

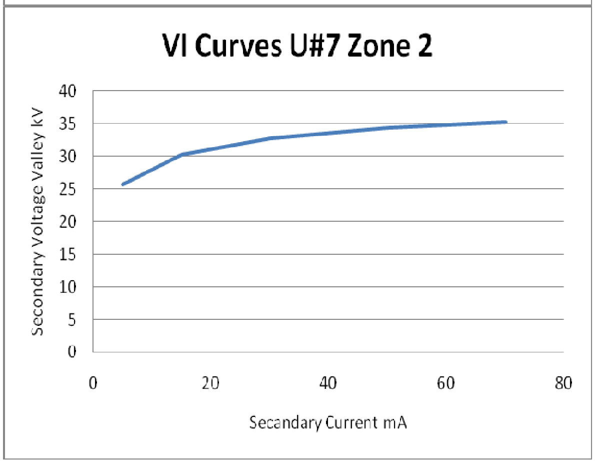
- Field 3-6 all clearly show back corona conditions. Apart from ESP Mechanical & Process issues it is also possibly clear, that either not right amount of SO3 is injected or SO3 is not very efficient to reduce resistivity for this type of fly ash. Further analysis in this regard need to carried out with ESP control optimisation & tuning.

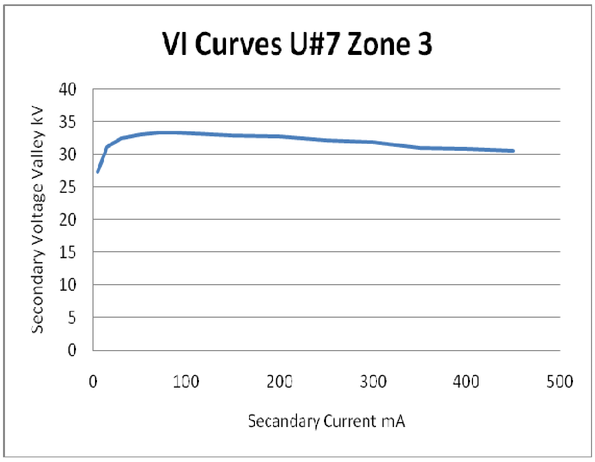
- The idea is to keep high current densities during the pulses to ensure good current distribution along the discharge electrodes. At the same time ensure low average current density to avoid back corona from the dust layer.

- The additional voltage in dirty condition is due to that the dust layer on the collecting plates, there will be a voltage drop over this dust layer adding to the voltage value. It could clearly be seen with PDR.and after a PDR, when the dust layer is removed, the voltage typically drops several kV which is common after an efficient PDR.

- Refer to the curves below for various zones based on the readings received from the Plant..







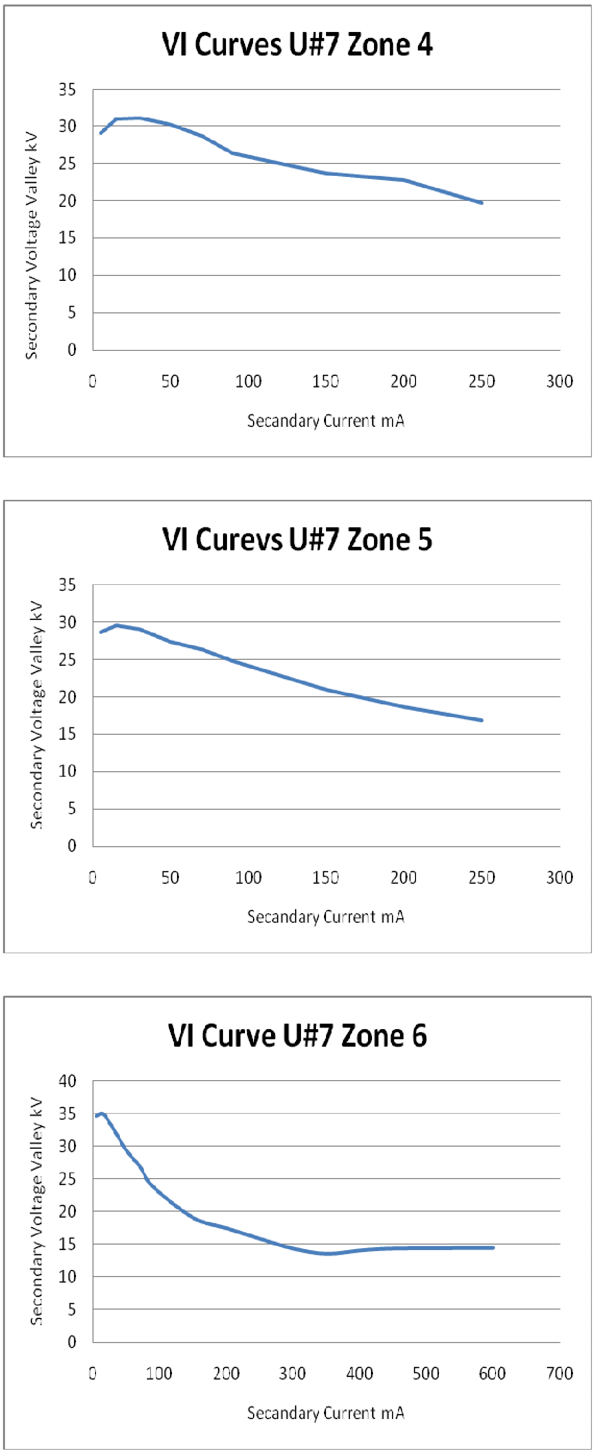


Fig. 2.2-2: Figure Dust V-I Curve from Zone 1 to 6

As way forward Alstom & Delta jointly decided to put High Frequency Rectifier units of 60 Kv/1000 mA rating, in first field of Pass A & D as a test case. Accordingly, 2 units were installed in early Dec'10.

The following curves will represent the previous and present status of those two fields in terms of Electrical Readings vis-à-vis Unit Load vis-à-vis emission level.

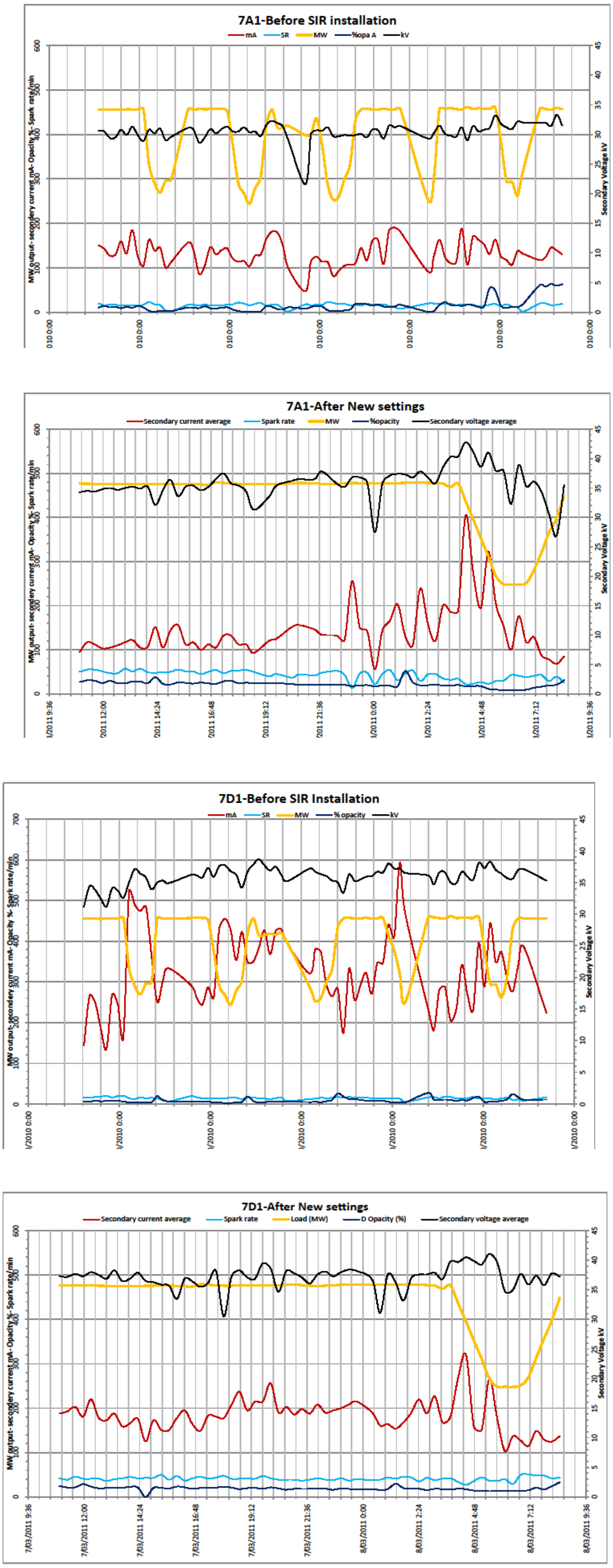


Fig. 2.2-3: Figure Electrical Readings vs Load vs. Opacity

2.3 Analysis

The above results can be put into following table for U7 A1 :

Parameter	With Conv.TR	With SIR
Load	350 (Av)	480
KV	30 (Av) 33 (pk)	39 (Av) 43 (Pk)
mA	130 (Av)	180 (Av)
Spark Rate	10 SPM	40 SPM
Opacity	~20 %	~20 %

From above data we can clearly understand :

1. Load has increased by 37%
2. Clear rise in Secondary Voltage
3. Spark Rate has increased substantially
4. Opacity remain same even with increase in load – a clear sign of better performance.

We have also analysed the comparative reading in all 4 passes on a particular day and it also shows Pass A & D has least Opacity Reading than Pass B & C

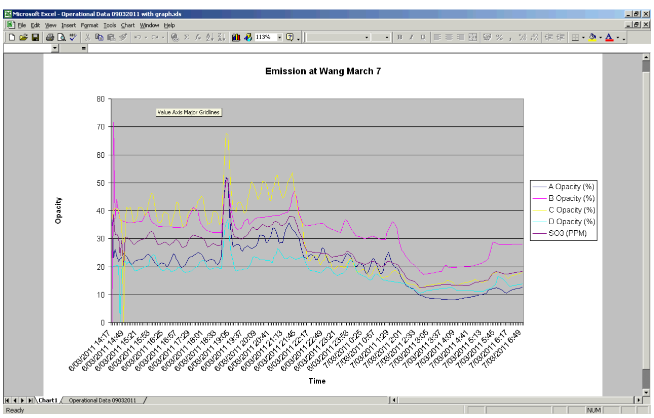


Fig. 2.3-1: Figure Opacity Comparison between all 4 passes

A comparison between the ESP operational voltages from line-frequency and high-frequency power supplies is shown in figure ….

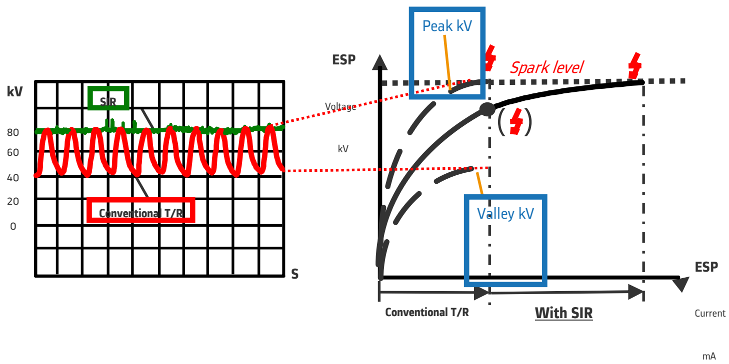


Figure 2.3-2. Ripple difference between a SIR and a conventional TR in same bus section gives a much higher current with SIR – when the current is limited by sparking.

The Power input is usually limited by:

- Sparking inside ESP, or
- TR current limitation, or
- A combination of both

A conventional TR provides the ESP with a HVDC superimposed with a ripple component of about 30-40% peak-to-peak. A SIR in the same ESP provides a HVDC with negligible ripple. With SIRs the kVarithmatic-, kVpeak and kVvalley values are for all practical purposes identical.

As the SIR output is controlled by transistors that operate at quite high frequency, the regulation becomes very fast, and the target to stay at highest possible kV is much better accommodated with SIRs than with conventional TRs.

The fact that a SIR very often is capable to deliver 2-3 times more corona power into the ESP can be very important for an old ESP, which may e g have loose discharge electrodes. With SIRs, sparking may sometimes be totally avoided by setting a kV or mA limit to a safe value below the sparking level – while the ESP can still operate at a much increased power level and reduced emission compared with conventional TRs.

The pulse time in SIRs can be substantially lower than in conventional TRs. Therefore, with SIR it is possible to stop and raise the HVDC flow at sparking and resume the HVDC much faster. This improves the ESP Collection efficiency, and is especially important for ESPs after Recovery Boilers.

As SIR uses more kV to inject same current in a given ESP field compared with a conventional TR, the increased kV with SIR accelerates the particulates better. We see often that it can be quite tricky to get in enough power in the first field of an ESP after a coal fired boiler, First Field collects 75 - 95% of the dust , the more the better. Our key question was always there what happens when we inject more power into the first field? First Fields are so limited in power input, we don't reach the Back-Corona region and with installing SIR even if we double the power input and do reach some Back-Corona that is always a better alternative.

On the other hand the EPIC IIs in rear fields are operating in Semipulse Mode with 1:1, 1:1, 1:3, 1:5 and 1:7 from Field 2 through Field 6.

The result discussed above is without any proper tuning so far and just putting some settings after commissioning. We strongly believe there still have enough potentials to improve the performance.

2.4 Conclusion

The above results with SIRs indicate that for aging Utility precipitators handling High Resistive Coal /Ash conditioned with SO3, SIR certainly provides a good solution, Not only can the overall ESP efficiency improve, the collection efficiency can increase to a point, that minor mechanical defects on the ESP internal parts may become permissible without exceeding emission limits.

In comparison with other available means to reduce emission, SIRs certainly give great value for money and the relative payback period may be very short indeed.

As SIRs installation is made only outside of the ESP, a big shutdown is never needed, which usually totally eliminates any plant production loss.

2.5 Literature

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