Ion Blast™ Precipitator

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1 Summary / Abstract

The history of electrostatic precipitator (ESP) is already longer than a century. Therefore ESP as an investment product is typically regarded as a mature technology with very limited prospects for major development steps. The Ion Blast precipitator technology however means a substantial change to the ESP philosophy and challenges the conventional ESPs. Ion Blast precipitators (IBP) utilize the ionic wind, which is specially indorsed by utilizing a doubled voltage level, up to 150 kV. At the same time the distances have been increased. An Ion Blast precipitator is typically a vertical cellular one-field-ESP with a self-supporting honeycomb structure. The hexagonal cells are significantly larger than in any conventional ESPs, the wrench opening of the cell is ca. 1.3 m. Ion Blast precipitators are highly competitive in price, maintenance costs and efficiency even with the challenging process conditions and in sub-micron particle removal.

2. The New ESP Philosophy

The trend in ESP design during the last century has been to increase the width of the passages between the collection electrodes. From 200 mm this width has been increased now to 400-500 mm. One factor to slow this development has been the still prevailing mainstream ESP philosophy according to which the turbulences inside the electrical field should be avoided.

The general idea has been to utilize the field and diffusion charging, but to ignore or merely avoid the ionic wind. Ionic wind in an ESP means that a gas flow is created in the direction of the electric field. The corona point discharge causes an entrainment of gas by moving ions.

Such a gas movement has been regarded as harmful in an ESP passage, where it has been desired that the gas flow penetrates the passage and ESP field at most uniform distribution of velocities as possible (Fig. 2-1). Thus all particles that are migrating towards the collection wall will not be returned backwards to the center of the passage.

Fig. 2-1: Conventional ESP passage (from the top) with a uniform gas flow not disturbed by ionic wind

From this point of view the idea to endorse the ionic wind and utilize it instead of trying to avoid it has been a controversy approach and against the ESP mains stream thinking. The Ion Blast precipitator invention and its development were based on the idea of how to really benefit from ionic wind. Ion Blast is the commercial name and GEA Bischoff's trademark for this type of dry and wet ESPs.

2.1 Ionic Wind

Ionic wind is a macroscopic gas flow towards the collection wall caused by the corona discharge due to the electrical high tension. Numerous measurements of the ionic wind in wire-plate and pin-plate electrode arrangements have been carried out (see [1] and [2] among many others).

However, all these investigations deal with the normal plate dimensions of mostly 400 mm. The electro hydrodynamic (EHD) effects, respectively the related flow turbulences are normally considered as disturbances in the field of conventional ESP.

As already mentioned, the Ion Blast precipitator utilizes the ionic wind caused by EHD (Fig 2-2). Therefore, even the smallest particles will get an additional drift due to the ionic wind flow and fly even faster towards the collection wall provided that the ionic wind is strong enough. This means that in an ESP utilizing the ionic wind, this ionic wind has to be much higher compared to conventional ESP technology.

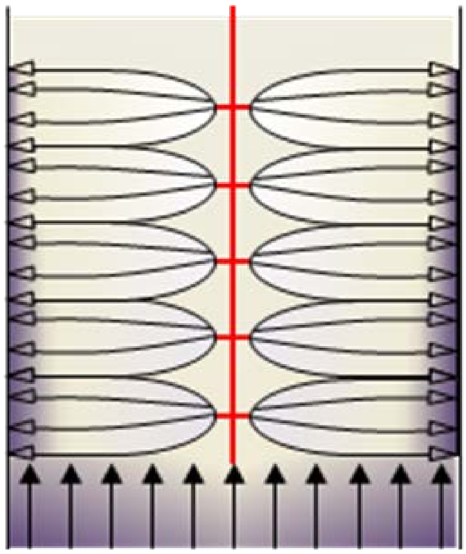

Fig. 2-2: Ion Blast cell (from the side) with strong non-overlapping ionic wind beams

The ionic wind in Ion Blast precipitators is achieved by:

1) Increasing the corona point discharge by:

    a. selecting discharge electrodes with very sharp needle points; and

    b. by utilization of higher secondary voltage levels; and

2) Increasing the ionic wind velocity by arranging:

    a. the needle point discharge electrodes at optimal distances;

    b. the non-overlapping beams of ionic wind at such short distance from each other that the maximum ionic wind velocity is reached.

This means that with the help of ionic wind - or the Ion Blast™ Effect, as we call it – the migration velocities of the most difficult particle sizes are increased from 0.1-0.2 m/s to 2-3 m/s.

Measurements in the high tension test field of GEA Bischoff GmbH in Frankfurt prove, that the ionic wind reaches velocities up to 3 m/s under conditions of ambient air (Fig. 2-3).

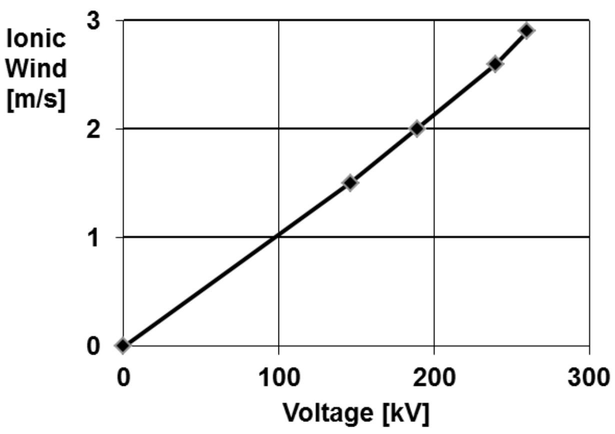

Fig. 2-3: Ionic wind vs. voltage

The ionic wind was measured close to the collection surface at the typical pin-to-plate distance of an Ion Blast precipitator of 400 mm. Additionally, the linear function of the ionic wind vs. tension is obvious. The related electrical behavior of the Ion Blast electrode system can be seen in Fig. 2-4.

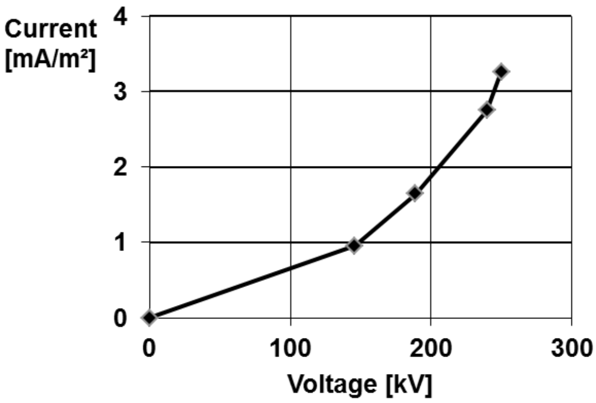

Fig. 2-4: Current voltage behavior

In the test rig voltages of even 250 kV could be reached while the specific current exceeded 3 mA/m².

2.2 The Wide-Space

In order to endorse the ionic wind, the secondary voltages typically used in Ion Blast precipitators have been substantially increased by a factor of 2 to 3 from the typical level used in conventional ESPs. They vary in practice, depending on the process conditions, between 100-150 kV (mean average value).

The high kV values consequently result from the much wider spacing inside the ESP. The Ion Blast precipitators are normally built as tubular precipitators either with round or hexagonal collection cells. The diameter of the round cells has varied between 1,000-2,000 mm whereas the hexagonal cells have normally a wrench opening of 1,290 mm (Fig. 2-5).

At first sight the Ion Blast precipitator may look like a conventional, vertical, wet ESP with one ESP field and a bundle of round or hexagonal pipes in parallel. However, in the Ion Blast precipitator the cell size is completely different and also the large needle point discharge electrodes in the middle of the cells.

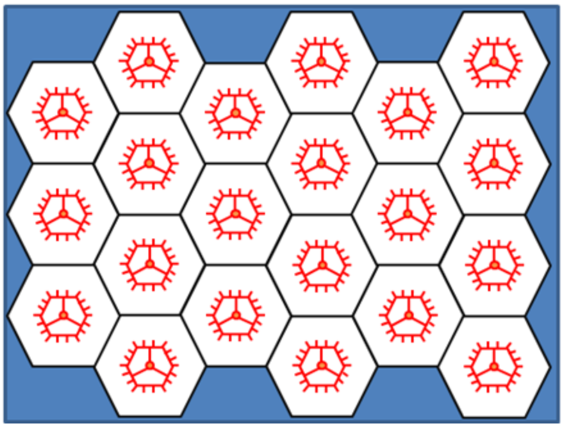

Fig. 2-5: Ion Blast precipitator honeycomb structure and discharge electrodes (from the top)

The increase of the cell size goes along with increased secondary voltage, but it also makes a challenge in regard to collection efficiency. The problem related to the difficult sub-micron particle precipitation in this wide space ESP cell is overcome by the ionic wind.

Ion Blast™ ESP means a significant change in ESP philosophy and at the same time in the ESP design. As a result of the wide-space structure, the specific collection area is radically reduced. This means that also the dimensioning calculations have been modified specifically for Ion Blast™ ESPs.

During the research and development phase of the technology, a unique dimensioning aid was developed and it considers also the particle size distribution information.

3. Benefits of the Ion Blast Precipitator

The wide-space structure brings several benefits:

1) When hexagonal cells are used this honeycomb structure is self-supporting and the casing is part of the collection electrode system.

a. In comparison to a conventional ESP, where a multiple amount of collection electrodes is supported from the ESP roof as dead weight, it is obvious, that the Ion Blast precipitator will have a lighter steel structure (Fig. 3-1).
b. Since the material, manufacturing and erection of the steel parts is the largest cost item in an ESP investment, Ion Blast precipitators are very competitive cost wise.

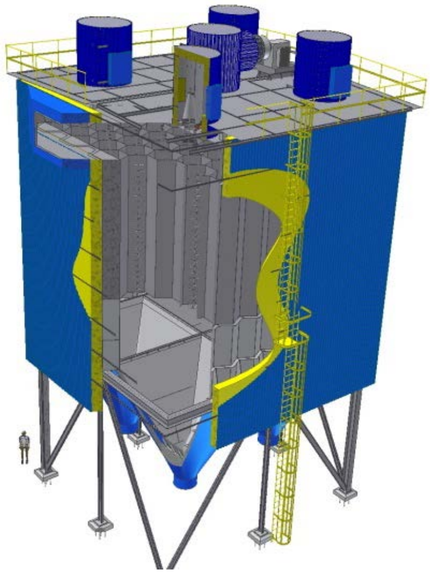

Fig. 3-1: A typical arrangement drawing of the Ion Blast precipitator

2) The substantially smaller specific collection area means that:

   a. Whenever there might be a problem with sticky dust, the area to be kept clean / cleaned is smaller.
   b. There is also more space inside the electrical field to arrange equipment for cleaning.

3) In a wet Ion Blast precipitators (wIBP), if liquid flushing is required:

   a. The amount of liquid to be used is much smaller than in conservative wESPs. Where the collection area is multiple.
   b. It is possible to have occasional or continuous on-line flushing.

4) All maintenance and inspections are easier, since there is a lot of space:

   a. It is easy to see that the discharge and collection electrodes and the rapping devices are unbroken and in their right positions; and
   b. The number of high voltage isolators is smaller than in conventional ESPs.

In dry Ion Blast precipitators the rapping is arranged by pneumatic vibrators. Therefore:

5) There are actually no moving parts in the dirty inside area of the ESP;

6) Due to the easy movement of the vibration wave movement in the honeycomb structure:

   a. the forces needed for rapping the collection electrodes are minimal; and thus
   b. much less destructive force is required for successful rapping than in the conventional ESPs, where the rapping hammers typically are used with 1,000 N forces.

The big distances also mean that the discharge electrode system can be very robust.

In fact, due to the robust design of the discharge electrodes (Fig. 3-2) no spare electrodes are needed.

Fig. 3-2: Hexagonal cells with wrench opening of 1,3 m and rigid discharge electrodes

4. Ion Blast Precipitators on the Market

There are already more than a hundred well operating Ion Blast precipitators - both dry and wet ones - delivered to various industrial processes and power plants.

More than ten Ion Blast precipitators are serving biomass incineration plants from 4-70 MW and gas volumes from 20,000-250,000 m^3/h. The main fuels are wood, peat, straw, REF, wood waste and sludge.

Fig. 4-1: Ion Blast ESP in a biomass power plant

Furthermore, Ion Blast precipitators were delivered to oil shale processing plants in Baltic countries.

One of the latest Ion Blast ESP was delivered to a spent acid regeneration plant for the chemical industry.

At this plant the inlet dust consists of PM_{10} particles, mostly sub-micron size. The measured outlet dust level is below 1.6 mg/m^3 (NTP).

The simplicity of the ESP structure makes this Ion Blast ESP more reliable than the conventional ESPs are in the difficult process conditions:

1) design temperature max. 470 ^oC,

2) over pressure max. 100 mbar; and

3) acid components inside the ESP.

Fig. 4-2: Ion Blast in the chemical industry

GEA Bischoff is actively on the market following new projects and promoting and offering Ion Blast precipitators.

5. Literature

[1] D. Brocilo, A. Berezin, J.S. Chang, Effect of the EHD Flow on Particle Surface Charging and the Collection Efficiency of Submicron and Ultrafine Dust Particles in Wire-plate Type Electrostatic Precipitators ICESP XI, Hangzhou, China,October 20-25, 2008

[2] Thorvald Ullum, Poul Scheel Larsen, Swirling Flow Structures in Electrostatic Precipitator, Flow, Turbulence and Combustion 73: 259–275, 2004.