Dust Extraction Process of DC Supply Ultra-Wide Electrode Distance

——Theory Overturning on Dust Extraction Process of Optimal Electric Spark Rate

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Abstract: This article is the summary of series paper of "Dust Removal Method of DC Supply Ultra-Wide Electrode Distance—The Theory Overturning for Dust Removal Method of Best Spark Rate".

This article will formally introduce three important invention achievements (including a number of invention patents and utility model patents):

First achievement: theory overturning for dust removal method of best spark rate.

Relate to: **control target** (fm);

form of electric field (structure of narrow electrode distance);

form of power supply (frequency power supply).

Second achievement: dust removal method of DC supply ultra-wide electrode distance.

Relate to: **control target (do), accurate control target (Io);**

form of electric field (structure of ultra-wide electrode distance);

form of power supply (DC supply).

Third achievement: "rectangle method" on automatic following control to dust concentration.

Relate to: **accurate control target (Io);**

principle of "rectangle method" on automatic following control to dust concentration;

F-series DC high voltage power supply with rectangle characteristics;

Therefore, we can reach a firm conclusion:

(1) The dust removal method of best spark rate and its theoretical basis have theory overturning;

(2) The dust removal method of DC supply ultra-wide electrode distance and its theoretical basis have been established, which will replace the historical role of dust removal method of best spark rate;

(3) The DC power supply with rectangle characteristics is the preferred power supply, which will replace the historical role of frequency power supply.

Key Words: Dust Removal Method of Best Spark Rate Dust Removal Method of DC Supply Ultra-Wide Electrode Distance Theory Overturning Manmade

0. Foreward

According to the principle on "**without destruction there is no construction, and there is both destruction and construction**", this invention has obtained the following **two important results** through "**two critical discoveries**" on logic defects etc. of concept of optimal electric spark rate, as well as "**three critical discoveries**" on mechanism of DC supply electrostatic precipitation etc.:

The first aspect is "Destruction": thoroughly overturn the dust extraction process of traditional optimal electric spark rate and its theoretical basis;

The second aspect is "Construction": propose and establish the dust extraction process of DC supply ultra-wide electrode distance and its theoretical basis.

We have seen a clear and unambiguous result, that is: on one aspect, through the criticism of this invention, the dust extraction process of optimal electric spark rate and its theoretical basis dominating the field of electrostatic precipitation for over half a century has been thoroughly overturned, thereby making it show the true features of "**epic on optimal electric spark rate**" without having the practical theory value and practical engineering value; on the other aspect, the **dust extraction process of DC supply ultra-wide electrode distance and its theoretical basis** of this invention has been relatively proposed and established, thereby filling the historical gap after sudden doom of dust extraction process of optimal electric spark rate and its theoretical basis through theory and engineering method.

We are going to make further summarization to the "**destruction and construction**".

1. Two Critical Discoveries Leading to Overturning of Dust Extraction Theory of Optimal Electric Spark Rate

As everyone knows, t**he dust extraction process of optimal electric spark rate** has **three**

elements:

First Element: Control Target Quantity – Optimal Electric Spark Rate f_m;

Second Element: Structure of Electric Field – Narrow Electrode Distance Type;

Third Element: Electric Power Supply – Power Frequency Type.

Please observe that the "three elements" form an organic whole, supplementing each other, and none is dispensable.

The dust extraction process of optimal electric spark rate and its dust extraction theory has been popular for more than 50 years in the world, the reason is that:

As the "**concept of optimal electric spark rate fm**" of control target quantity, they look quite "fair and reasonable", which has huge false or misleading, thereby making people wrongly perceive that: under the condition of so-called optimal spark rate fm, the optimal dust extraction efficiency **ηm** shall be obtained, in addition, this optimal dust extraction efficiency **ηm** is the maximum dust extraction efficiency η_M, which might be obtained by electric field of dust collector. Therefore, the expensive, hardly implemented, and difficultly maintained on-line monitoring devices for dust concentration d_0 need not to be installed.

We notice that, the above-mentioned so-called electrostatic precipitation method or dust extraction theory is actually the results generated by some false or misleading or technical prejudice of the "**concept of optimal electric spark rate fm**".

The "**two critical new discoveries**" of this invention have thoroughly revealed the essence of above-mentioned "**false or misleading**" or "**technical prejudice**", which is a puzzling problem to people for a long time. Therefore, it leads to the **thorough overturning of dust extraction process of optimal electric spark rate and its theoretical basis.**

1.1. First Discovery: The concept of optimal electric spark rate has logical defect [1]

We have discovered that:

The concept of optimal electric spark rate has serious logical defect: starting from the concept of "optimal dust extraction efficiency **ηm**", we can define that the corresponding discharge rate of electric spark is the "**optimal electric spark rate fm**"; however, when you want to obtain the so-called "optimal dust extraction efficiency **ηm**" in accordance with the defined optimal electric spark rate fm, you not always obtain **ηm.** That is to say, **the "positive logic" of**

concept of optimal electric spark rate is fair and reasonable, however, its "opposite logic" is unreliable or incorrect.

Therefore, the specific conclusion of this invention is: the discharge frequency f of electric spark is not correspondingly related to dust extraction results, and we can't take the optimal electric spark rate fm as the control target quantity of optimized electrostatic precipitation results.

We notice that, **taking the "optimal electric spark rate fm" as the control target quantity is the essence of dust extraction process of optimal electric spark rate and its dust extraction theory. Therefore, the discovery of above-mentioned logical defect of concept of optimal electric spark rate is the fateful impact to dust extraction process of optimal electric spark rate and its theoretic basis.**

Therefore, we can say that, the discovery of this logical defect is one of the critical discoveries of this invention on overturning the dust extraction process of optimal electric spark rate and its theoretic basis.

1.2. Second Discovery: the optimal electric spark rate f_m has the "man-made" attributes[2]

The reason for optimal electric spark rate fm becoming the "control target quantity" of electrostatic precipitation for optimized dust extraction results is that its theory thinks that: under the certain dust extraction condition, the optimal electric spark rate fm is one and only, which is one-to-one corresponding to optimal dust extraction efficiency η_m, namely, **η_m is an objective quantity value determined by electric field condition of electrostatic precipitator, which is the unique value, and is the maximum value η_M, without relying on human controlling wills.**

However, **we discover that:**

In practical control method and theory of dust extraction process of optimal electric spark rate, the optimal electric spark rate **fm** not only depends on **equivalent internal resistances r_1, r_0 of power supply**, but also depends on **control strategy factors m and n**. **r_1, r_0, m and n etc. are all man-made factors depending on controlling wills, and are not directly related to efficiency η_m of dust extraction.** Therefore, people can arbitrarily design, produce, and change any or all parameters in them, so as to obtain the expected fm value. See the following math conditions **(2), (6), and (8)** satisfied by various parameters **r_1, r_0, m** and **n, which are related to fm value:**

$$\frac{dU_i}{dI} = r_0 \quad ---(2)$$

Thereinto, r_0 is the equivalent internal resistance of power supply;

$$-(r_1 + I\frac{dr_1}{dI}) = r_0 \quad ---(6)$$

Thereinto, $\mathbf{r_1}$ is the variable component of equivalent internal resistance of power supply;

$U_i = (2 - \frac{1+2m+n}{6000} \bullet f) \bullet \frac{U_p}{\pi} \quad ---(8)$, Thereinto, ***m*** =1,2,3…; ***n*** =1,2,3….

That means that, in fact, the **quantity value fm of optimal electric spark rate has obvious "man-made" attributes**, leading to optimal value η_m of dust extraction efficiency, and maximum power station voltage value of dust precipitator **Uom** etc. In addition, the quantity value **also has obvious "man-made" attributes, they don't have the "uniqueness attribute" of control target quantity making optimized dust extraction results.**

Therefore, the discovery of "man-made" attributes of **fm, η_m, Uom** etc. thoroughly denies the feasibility of "taking the optimal electric spark rate fm as the control target quantity on obtaining optimized electrostatic precipitation results" from theory, which is the more fateful impact to dust extraction process of optimal electric spark rate and its theory basis.

Therefore, we can say that the discovery of "man-made" attributes fm, η_m, Uom is another critical discovery of this invention on overturning the dust extraction process of optimal electric spark rate and its theoretic basis.

1.3. Brief Summary

We notice that the discovery of logical defect of concept of optimal electric spark rate, and the discovery of "man-made" attributes have fateful impacts to dust extraction process of optimal electric spark rate and its theoretic basis. In other words, the above-mentioned two new discoveries of this invention have led to thorough overturning of dust extraction process of optimal electric spark rate and its theoretic basis.

2. Three Critical Discoveries Leading to Establishment of Dust Extraction Process of DC Supply Ultra-Wide Electrode Distance

In fact, the **destruction process** to traditional dust extraction process of optimal electric spark rate and its theoretical basis is interactively carried through or simultaneously carried through with the **construction process** to dust extraction process of DC supply ultra-wide electrode distance and its theoretical basis. That is to say, with the above-mentioned "two critical new discoveries" used for overturning the dust extraction process of optimal electric spark rate

and its theoretical basis, this invention has also successively made "**three critical new discoveries**" used for constructing the **dust extraction process of DC supply ultra-wide electrode distance** and its theoretical basis, which can be referred to as:

"Electricity saving mechanism", "rectangular following control mechanism", and "maximum value of dust extraction efficiency η_M".

The above-mentioned "dust extraction process of DC supply ultra-wide electrode distance" is composed of its **"three elements":**

First Element: Control Target Quantity – Dust Concentration do or Standard Dust Concentration Io;

Second Element: Structure of Electric Field – Ultra-Wide Electrode Distance Type (same electrode distance 500 mm – 800 mm);

Third Element: Electric Power Supply – DC Supply Type (power supply containing DC component).

We notice that the "three elements" form an organic whole, supplementing each other, and none is dispensable.

2.1. First Discovery: the electrostatic precipitation adopts electricity saving mechanism of DC supply [3]

We discover that:

Under the conditions basically corresponding to results of electrostatic precipitation, about 90% electric energy will be saved by adopting DC supply than adopting traditional power frequency supply, which has been tested and verified by many engineering practices of electrostatic precipitation.

This means that, the adoption of DC supply not only can obtain bigger even maximal dust extraction efficiency η_M for electrostatic precipitation, namely, when the electrostatic precipitation reaches the target of "**qualified emission**", it can **save about 90% electric energy**, thereby being "**good and saving**".

This new discovery has laid the foundation for DC supply returning the field of electrostatic precipitation abandoned by the dust extraction theory of optimal electric spark rate or for the establishment of dust extraction process of DC supply ultra-wide electrode distance of this invention.

2.2. Second Discovery: the rectangular following control mechanism of

dust concentration [4]

We discover that:

Under the status of normal dust extraction, the characteristics of current-voltage diagram of dust precipitator electric field on "**negative correlation of electric field current Io and average value δ of dust concentration inside electric field**" and the "rectangular load characteristic" of F-series DC supply of this invention can **appropriately combine** (see the following **Figure 21**) **to generate an "automatic following control to dust concentration δ" or control law, namely**: when the dust concentration inside the electric field increases, the electric field voltage Uo will automatically rise, thereby making the dust concentration δ reduce; on the contrary, when the dust concentration decreases, the electric field voltage Uo will automatically reduce, thereby saving the electric energy; and this process is completely self-adapting.

The discovery to **dust automatic following control mechanism** is the "**dust extraction process of DC supply ultra-wide electrode distance**" of this invention, drawing on "**taking the standard dust concentration Io as the standard control target quantity**" to reach the purpose on qualified emission of dust extractions system, which has laid the theoretical basis and found an engineering implementation method with superior performance, and also has advantage on further energy conservation. It may be said "**achieving many things at one stroke**".

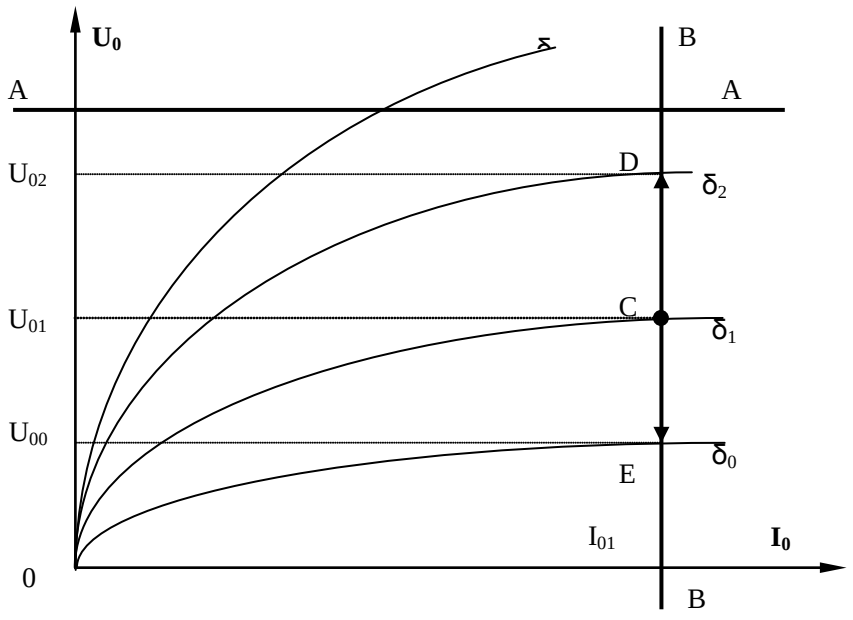

Figure 21 Schematic Diagram of Rectangular Automatic Following Control

2.3. Third Discovery: the maximum value η_M of dust extraction efficiency can be obtained for DC supply [4]

When discovering the "**man-made attributes**" for optimal dust extraction efficiency η_m of dust extraction process of optimal electric spark, through analysis and reasoning, **we also discover that**:

For the so-called optimal dust extraction efficiency **ηm** obtained from traditional dust extraction process of optimal electric spark rate adopting the power frequency supply and its dust extraction theory, and the maximum dust extraction efficiency η_M obtained from dust extraction process of DC supply ultra-wide electrode distance and its dust extraction theory, they have the following relationship, which has been tested and verified by a series of engineering practices of electrostatic precipitation:

$\eta m < \eta_M$, and normally **$\eta m << \eta_M$**.

It is tested and verified that:

This new discovery shows that, DC supply not only can be used for electrostatic precipitation, and can obtain bigger even maximal dust extraction efficiency η_M of dust precipitator electric field comparing to traditional power frequency supply.

We notice that, this not only has cleaned the theoretic obstacle for DC supply returning the field of electrostatic precipitation, and also has established sufficient confidence for reaching the target of "qualified emission" for electrostatic precipitation of DC supply.

Therefore, this discovery has important realistic significance.

2.4. Brief Summary

It is thus clear that, three new discoveries of electricity saving mechanism, rectangular mechanism, and maximum value η_M of dust extraction efficiency have paved the way for DC supply returning the field of electrostatic precipitation and establishing the "dust extraction process of DC supply ultra-wide electrode distance and its theoretical basis", thereby leading to debut a new-conceptual dust extraction process of DC supply ultra-wide electrode distance with "reliable emission reduction and target realization, more electric energy conservation, and more resource conservation. "

3. "Rectangle Method" for Automatic Following Control of Dust Concentration

In fact, we had exposed the invention achievement of "rectangle method" for automatic following control of dust concentration on **ICESP-X** Australian Conference in 2006. We will make specialized discussion in series articles on *Dust Extraction and Gas Purification*, and we won't

unfold this temporarily.

Here we will emphatically introduce main technical characteristics, or main advantages of F-series DC high voltage with "rectangle characteristic".

We only introduce the following two prominent **technical characteristics** of **F-series DC high voltage power supply**:

3.1. First Technical Characteristic: it has "rectangle load characteristic"

(1), Automatic following control of dust concentration; (see rectangle characteristic of **Figure 31**; following speed ≈ **ms** level (**Figure 32**))

(2), Construct the system of "Standard Control Target Quantity Io"; (see rectangle characteristic of **Figure 31**)

(3), Long-term underloading, no-load, and short circuit are permitted. (See **Figure 32** waveform of high voltage current Io during short circuit, and **Figure 33** waveform of inverting current I1 during short circuit))

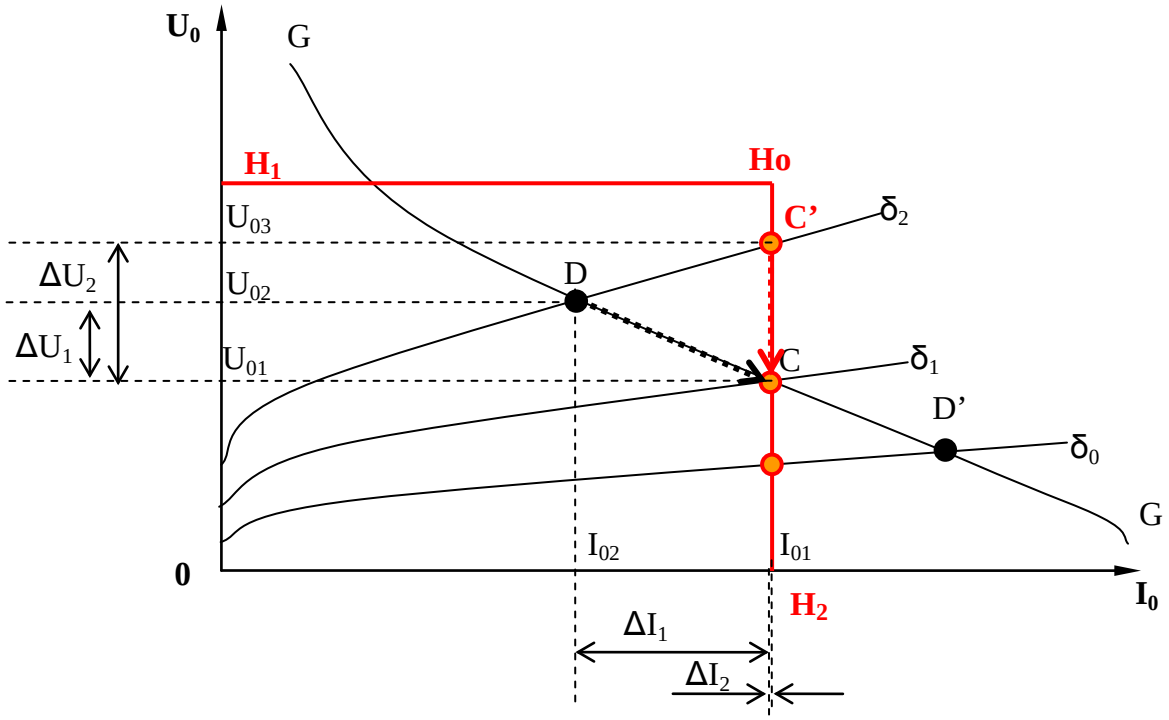

Figure 31, Schematic Diagram of Automatic Following Control of Dust Concentration

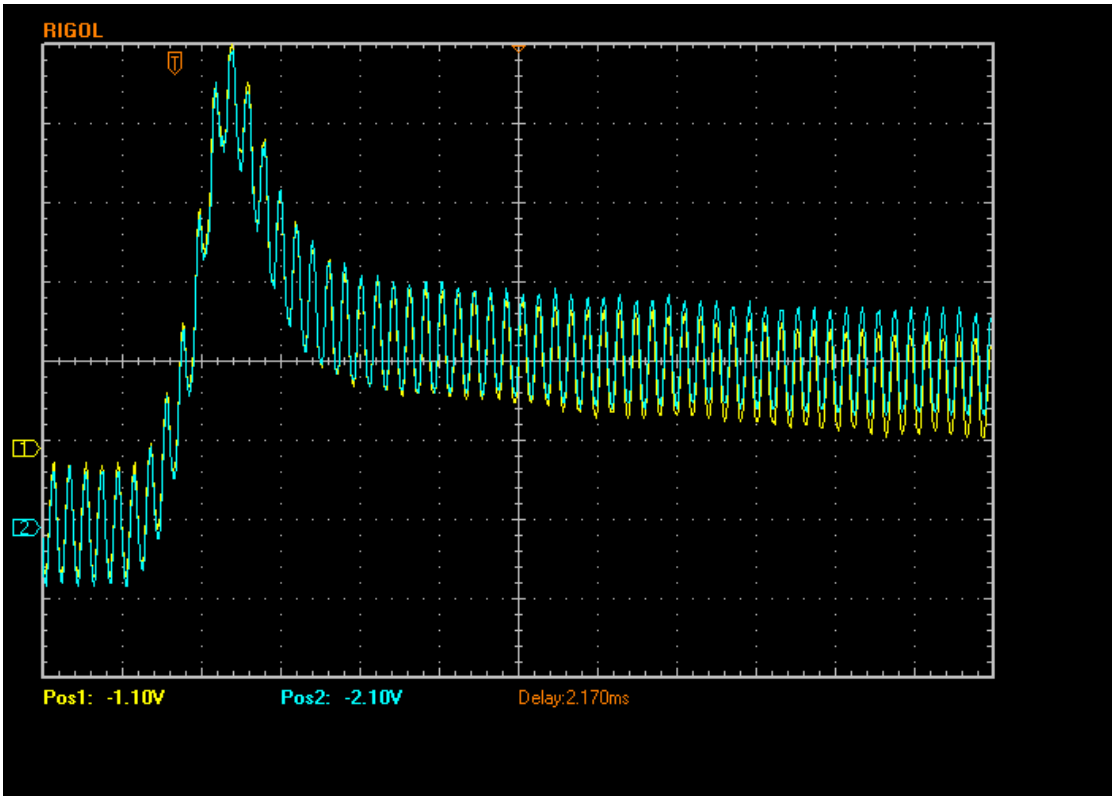

Figure 32 High Voltage Current Io-t Curve During High Voltage Short Circuit (Control Transition Process t_{Σ}≈1-3ms)

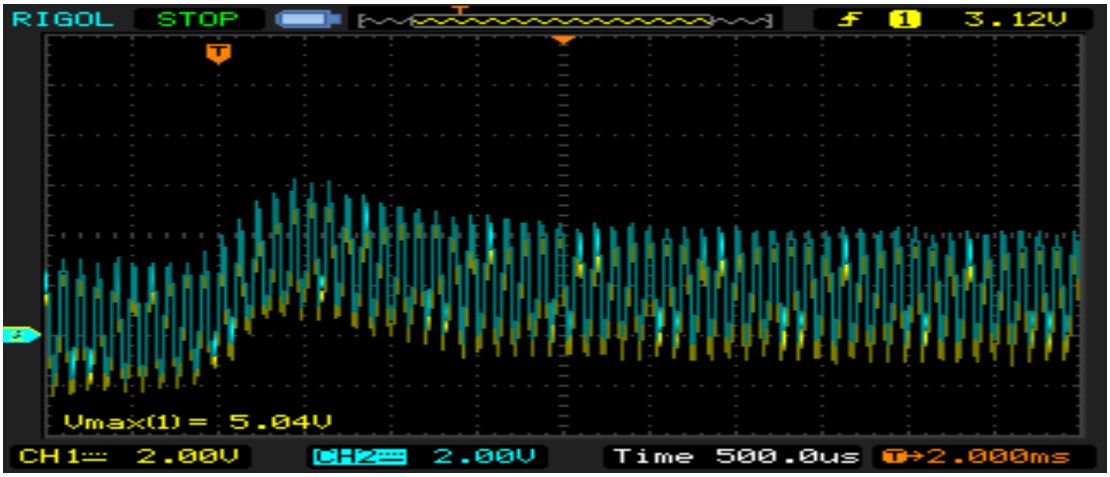

Figure 33 Inverting Major Loop Current I_1-t Curve During High Voltage Short Circuit (Current during Working Status I_1=21A, Current during Short Circuit Status I_1=29A)

3.2. Second Technical Characteristic: it has “SCR-SCR” control inverting system structure

(1), Pure distributed parameter type SCR high-frequency and high voltage inversion; (See **Figure 34** Schematic Diagram and **Figure 35** Inversion Waveform)

(2), "SCR-SCR" Control System; (high voltage underloading operation, open circuit operation, and short circuit operation are permitted); (See **Figure 32, 33**)

(3), High reliability. (See Figure 36 Interruption Process During Failure of **SCR** Inversion)

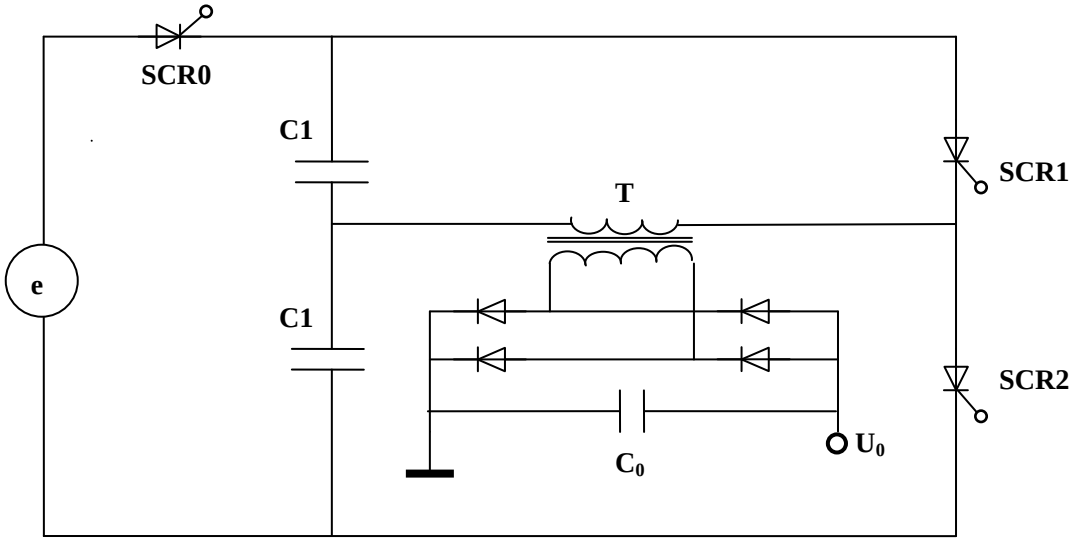

Figure 34 Complete Distributed Parameter Type SCR Half-Bridge Inversion Schematic Diagram (F-Series Power Supply)

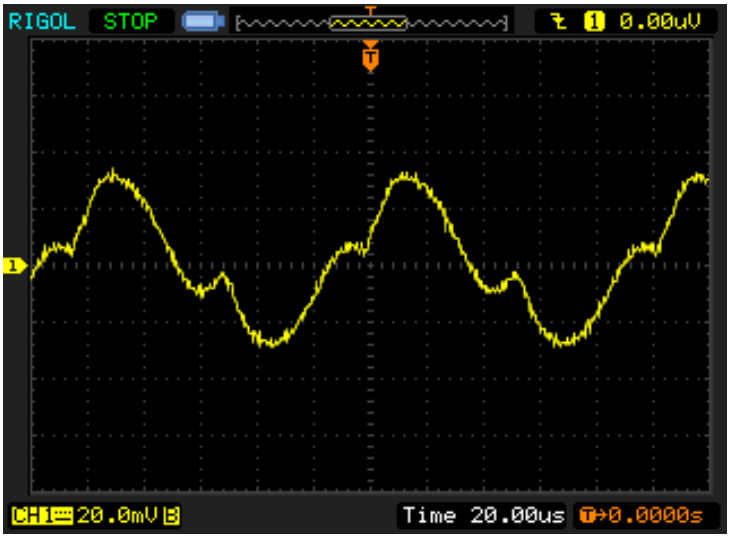

Figure 35 Distributed Parameter Inversion Current Waveform (f=10khz)

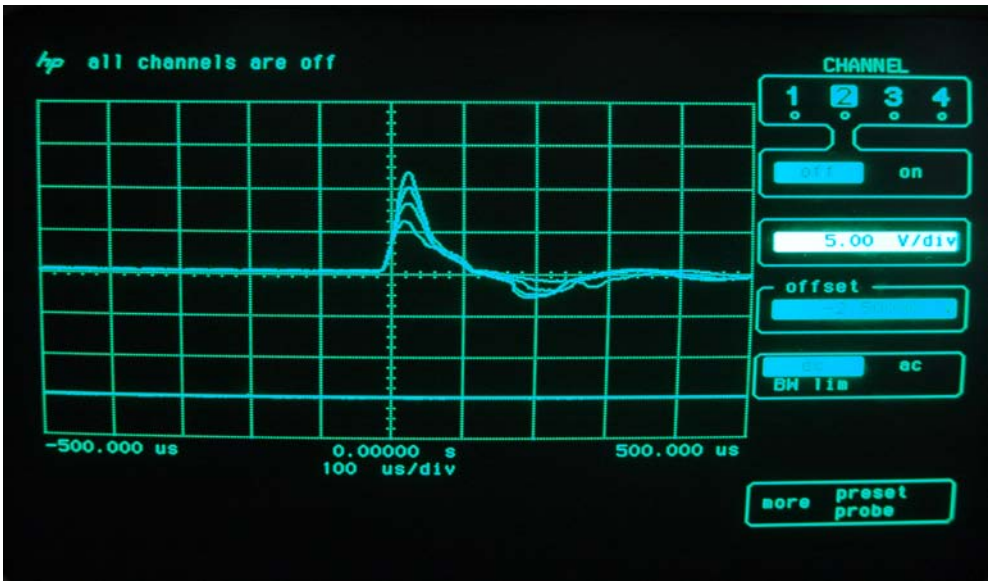

Figure 36 Shutoff Process i_1-t During Failure of SCR Inversion (Shutoff Process t_{off}≈100μs)

3.3. Practical F-Series High-Frequency High-Voltage Inversion DC Supply

Figure 37, F-Series High-Frequency High-Voltage Inversion DC Supply developed by **Shijiazhuang Automation Research Institution**, and manufactured by **Shijiazhuang Weituo Technology Co., Ltd.**

The overall structure is: high-voltage oil tank with control boosting integration structure and without external type. Thereinto,

Figure 38, F-Series DC Supply in Shuangliang Group Power Plant

Figure 39, F-Series High-Frequency High-Voltage Inversion DC Supply obtained First Prize on Development of Science and Technology in Shijiazhuang

Figure 37, F-Series High-Frequency High-Voltage DC Supply (Right Figure is Internal Type High-Voltage Oil Tank)

Figure 38, F-Series Power Supply (12 Units on Left Side) and Power Frequency Power

Supply "Put on a Rival Show" in Shuangliang Group

Figure 39, F-Series High-Voltage obtained First Prize on Development of Science and Technology in Shijiazhuang (2005)

4. Effect and Significance

The effect and significance of this invention can be summarized into the **following four points**.

4.1. Direct Effect and Significance

The dust extraction process of DC supply ultra-wide electrode distance can effectively overcome main disadvantages of traditional dust extraction process of optimal electric spark rate on "**not guaranteeing qualified emission, much electric energy consumption, and much steel consumption**", and reach the goal of "**qualified emission, about 90% electric energy conservation, and 10%-20% steel conservation**", thereby promoting the great development of sustainable development with "emission reduction, energy conservation, and resource conservation".

4.2. Indirect Effect and Significance

In accordance with is invention, the "dust extraction system of DC supply ultra-wide electrode distance" can be developed, so as to reform or replace the traditional dust extraction system of optimal electric spark rate, which will face a huge market around the world, **resulting in enormous direct or potential social and economic benefits.**

4.3. Related “general technology standard” will be generated

With wide range of promotion and application for **dust extraction process of DC supply ultra-wide electrode distance** of this invention, new **general technology standard** will be generated, which will result in enormous economic benefits and will greatly increase the **speak rights** of China in the field of electrostatic precipitation.

4.4. Theoretical Promotion Effect

In accordance with this invention, the traditional dust extraction process of optimal electric spark rate being popular in the world for more than half a century has been thoroughly overturned, and a dust extraction method of DC supply ultra-wide electrode distance with brand new concept and its theoretical basis has been constructed, thereby “ensuring qualified emission, saving about 90% electric energy, and saving 10%-20% steel” etc. It’s not a question, whether for theory or for engineering method, this invention is a key breakthrough in the field of electrostatic precipitation. This breakthrough surely will promote a significant technological change in the field of electrostatic precipitation, thereby resulting in more new theories and new methods in favor of improving emission indexes, saving electric energy, and saving resources, so as to benefit Chinese people and people all over the world.

5. Author’s Suggestion and Acknowledgments

5.1. Suggestion

Suggestion 1, As the letter the author of this article initially wrote to the editorial department of *Dust Extraction and Gas Purification*:

Because the involved issue overturns the **dust extraction process of optimal electric spark rate** and its theoretical basis being popular for more than half a century, which proposes and constructs a new **dust extraction process of DC supply ultra-wide electrode distance and its theoretical basis**, being profound and heavy. It will inevitably lead to wide attention and hot topic from related experts, scholars, as well as engineers and technicians, thereby generating a series of academic impact in method of thinking, concept, and principle etc. I welcome this and would like to actively participate in discussion under the principles of seeking truth from facts, presenting facts and reasoning things out.

Of course, if necessary or willing, I also welcome related leading departments including the editorial department of *Dust Extraction and Gas Purification* or China Electrostatic Precipitation Society etc. to publish guiding articles with clear and definite academic tendency, or to organize

special seminar, so as to improve the results of academic discussion.

Suggestion 2, the author considers that, through the previous four papers [1,2,3,4] published in public and twelve papers published in this publication, the traditional **dust extraction process of optimal electric spark rate and its theoretical basis** have been thoroughly overturned, and a **dust extraction process of DC supply ultra-wide electrode distance and its theoretical basis** with brand new concept have ben preliminarily constructed. For the development of science and technology in the field of electrostatic precipitation, this is a big deal, which will inevitably lead to a series of significant technical change.

Therefore, for the dust extraction process of DC supply ultra-wide electrode distance, although the author has obtained certain successful experiences from Shougang Group, Shuangliang Group, and Laigang Group etc., however, those experiences are initial and not perfect. In addition, the technology, capital, and capability are all limited, which will appear small forces with quite slow progress in the face of extremely tremendous market in foreign and domestic electrostatic precipitation. The author considers that, the most urgent work is to obtain vigorous support from famous entrepreneurs in power supply, body or integral dust extraction system in industry for cooperative development, promotion, and application of newest patent technology of "**dust extraction process of DC supply ultra-wide electrode distance and dust extraction system**" (you can register the patent website to inquire about multi-terms of **2005100125366, 200910075132, and 2009201042519**), so as to seize the commanding height, establish the normalized sample demonstration project, prepare to construct the technical specifications in this spring tide of technical change, and make contributions for the country and people. Please contact the editorial department of *Dust Extraction and Gas Purification* or the author for specific systematic problems and specific technical problems on constructing the "**dust extraction process of DC supply ultra-wide electrode distance and its dust extraction system**" in accordance with "**three elements**". **Thanks for your cooperation.**

Suggestion 3, The author suggests that, the **high-voltage power supply of electrostatic precipitation** for future development shall have the following most essential **technical characteristics**:

(1), DC Type

It is the **DC high-voltage power supply** arbitrarily containing direct voltage component and the voltage is not transient zero, such as high-frequency inversion rectifier type power supply, three-phase rectifier type power supply, multi-phase mid-frequency inversion rectifier type power supply, sing-phase power frequency rectifier filtering type, and medium-frequency inversion

rectifier filtering type power supply etc., including the power supply loaded with high-frequency impulse.

(2), Rectangle Load Characteristic

○ Rectangle **load characteristic** is the optimal load characteristic of high-voltage power supply of electrostatic precipitation;

○ It is not afraid of underloading operation, no-load operation, or short-circuit operation;

○ It has automatic following control functions to dust concentration, and has high following control sensitivity;

○ It can constitute the electrostatic precipitation system of “taking the load current Io as standard control target quantity”, thereby creating fundamental conditions for implementing the “dust extraction process of DC supply ultra-wide electrode distance”

5.2. Acknowledgements

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References

[1] Zhao Fu ,etc. Query on the Sustainable Development of Traditional Dust Precipitation Using Optimal Electric Spark Rate . ICESP.XI,CHINA HANGZHOU. October, 2008

[2] **Zhao Fu, etc.** Questioning on Theoretical Basis of Dust Extraction Process of Optimal Electric Spark Rate – Analysis on Control Strategy of Optimal Electric Spark Rate

for Traditional SCR Power Frequency Supply, Documents of China Thirteenth Electrostatic Precipitation Academic Conference, Qingdao, 2009, October, P 331

[3] **Zhao Fu ,etc.** Discovery of The Power-saving Principle of Electrostatic Dust Precipitation Using DC Supply. **ICESP.X,** AUSTRALIA, June, 2006

[4]. **Zhao Fu ,etc.** The Rectangular Controlling Principle and Method of Automatic Following Control on Dust Density in Electrostatic Dust Precipitation. **ICESP.X,** AUSTRALIA, June, 2006

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