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STUDYING AND APPLYING THE EFFECT OF WHIRLING AIR STREAM IN ESTABLISHING CENTRIPETAL WET – FILTER PRINCIPLE

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ABSTRACT

In wet filter method, principles which are proposed and applied include: empty cask to wash air; tower with a lay of buffer; tower to bubble up water; centrifugal equipment, inertia equipment and Ventury equipment. As being applied in Vietnam condition, these equipment, in spite of solving partly air pollution causing by dust, still have some shortcomings: being obstructed by dust and precipitates appearing from side effects; operating unstably and low capacity. Establishing a new wet-filter principle to improve capacity and stableness of equipment is urgent and necessary at the present.

Whirling air stream or eddy in nature has important principle that is creating a whirling air stream with high speed; especially this air stream can collect dust in side it. This is the most important and necessary point for the author to apply to establish the centripetal wet-filter principle.

The researching results on model designed in real size and applied in many factories and enterprises show that this is an equipment with simple design and operation, low cost, acceptable current consumption, high effect and stable productivity.

The author would like to propose a new dust wet-filter principle beside six principles as mentioned above that is centripetal wet-filter – the seventh wet-filter principle.

Keywords: Centrifugal, centripetal, solvent, velocity, wet-filter, whirling air stream

Introduction

General

The main point of dust and poisonous gas filtering process is to pull dust and poisonous gas out of polluted air stream before being discharged into the environment and it can be carried out by many different ways. Practically, people usually combine dust and poisonous gas treatment by wet filter method with equipment: empty cask to wash air, tower with a lay of buffer, tower bubble up water, centrifugal equipment, inertia equipment and Ventury equipment. The wet filter method has some following advantages:

- The equipment of wet filter is easy to make, low price but very high efficiency;
- Dust which have size under 0,1 μm can be filtered (Ventury equipment);
- It can operate with high temperature, high humidity with that other equipment can not satisfy. This equipment not only filters dust but also treats poisonous gas.

However, some following phenomena happen when it is applied in Vietnam:

- The equipment operates unstably, low capacity;
- The essence of dust in Vietnam condition usually has dust and poisonous gas in high temperature with various and complex components so it's easy to make "choke" phenomenon or obstruct equipment.

Raising filter efficiency and improving shortcomings mentioned above is content which author expects to gain in his study.

Some studies in and out the Vietnam

In foreign countries, there are some authors such as V.Ianischevsky [11, 12].1976, Xtepanov B.B [15].1980, Sui.Kh.1966, Alimov.P [20].1970, Berunsky B. akol [13].1975 Czech and Poland have had many studies on applying whirling air stream to ventilate factory and mine.

Other authors in Vietnam also have applied the effect of whirling air stream to ventilate and eliminate toxicants in factory like the studies of Dr. Quan N.V. – "Ventilate room, summing up report of science study", HCMC, 1995; "Specific of dust and poisonous gas in diagram of ventilating room. Labor magazine", 4/1997.

The above studies have some following disadvantages when they are applied in practice:
- The most suitable size room must be small or round.
- Equipment in factory obstructed wind and easily to make muddled wind areas
- When concentrating with high density in the center, dust and poisonous gas will be dangerous for workers if it is not treated timely.

V. Ianischevsky has studied whirling air stream by model made from air distribution equipment placed in corner and polluted air will be thrown outside the construction by a hole at the top. The results showed that this method guarantees room space is ventilated and there is no "dead" area in center of the construction.

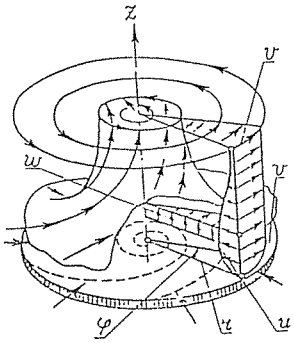

Figure 1.1: Movement of air stream on the bottom surface

In which:
u : centripetal velocity
v : around velocity
w : axial velocity
φ, r, z : Axis

Some Russian and European authors also had similar studies while applying whirling air stream. Figure 1.1 shows that because of centripetal force's effect, whirling stream has tendency to reduce their section during moving up. The characteristic of whirling air stream is able to collect dust into the center of whirling core. Dust and poisonous gas in whirling stream will move for longer distance which is the main reason increasing contact surface between dusts, poisonous gas and liquid drops in the above space. From this phenomenon, when letting whirling air stream contact with smooth, small size (100 ÷ 300 μ) dew, the heavy density at the area of whirling core has a big effect to filter dust and poisonous gas.

Methods

Designing model

Based on applying the advantages of effect of whirling air stream and dew making technology, experimental model is built with following basic size:
- Choosing air stream flow: L = 4.000 – 4.500 m^3/h
- Choosing air stream velocity through horizontal section: v = 2,20 ÷ 2,50 m/s
- Equipment diameter: 800 mm
- Height: H = 1.750 mm
- Fan capacity: N_{qg} = 5 HP

- Fan capacity of dew ejecting equipment: 0,5HP
- Making poisonous gas equipment by combustion chamber includes ejector, oil heater, high pressure fan 400 m^3/h, h = 800 – 1.000 mm H_2O.

Operating principle of the equipment:

- The air contains dust taken into the low part of equipment based on principle of making counter-force to make disorder between air stream and moving liquid stream in stream core.
- Dust or poisonous will be kept in the liquid based on principles of clashing, contacting or diffusing. After contacting with solvent, dust and poisonous gas will be discharged through humid prevented layer out off the high part of the equipment and liquid stream will fall down the bottom of the equipment. This liquid circulates with calculated circle to improve wet filter capacity of the equipment.

Experimental results

The components of dust were identified with some following parameters:
Separated natural weight: $\gamma_{tn} = 0,899 g/cm^3$
Humidity:w = 4,88 %
Dry natural weight:$\gamma_k =$ 0,605 g/cm^3

After analyzing, gain components had mainly size about 10 ÷ 50 μ (85%), the rest is 10 ÷ 2 μ.
Experimental results showed that suitable air stream velocity to make the best whirlwind is about 26–2m/s and the height of water layer at the bottom of equipment to make the best whirling core is about 8– 12cm.

Based on identifying logically input air velocity and height of water layer at the bottom of equipment, the experiments were carried out at dust concentration vary from hundreds to nearly 10,000 mg/m^3. The experimental result is showed on figure 1.2.

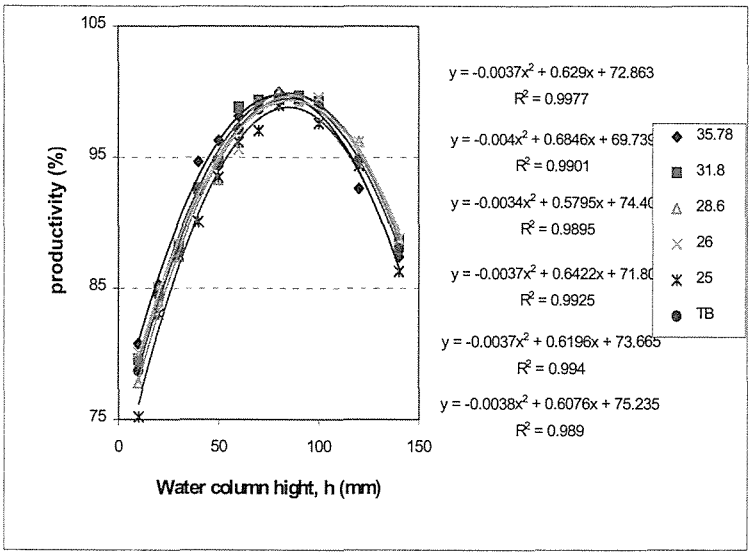

Figure 1.2. General of equipment productivity at different velocity

From the above experimental results also, when we use SPSS model for Window:
$\eta = - 0,003759 x^2 + 0,636346 x + 72,731 R^2 = 0,9883$

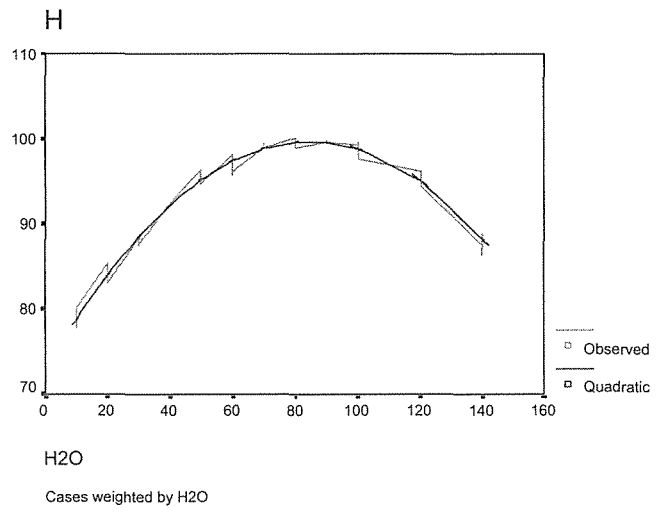

Figure 1.3. Depending of equipment productivity on height

Results

1. Dust treatment productivity of the equipment gets so high in almost test for input dust concentration varying in very large interval from hundreds to nearly 10.000 mg/m^3. That means the equipment productivity depends unnoticeably on input dust concentration and size in the experimental interval.

2. Appreciate velocity for the most stable treatment is about 26 ÷ 32 m/s, this value is also fix with other velocity value that the author has applied in practice with some constructions.

3. If the height of bottom water layer is about 60 ÷ 80 mm, equipment productivity get 97% evenly and rather stable. The maximum productivity is up to 99% at H = 80 mm in almost experimental times.

4. By practical observation of the model, we see the maximum height of whirlwind is about 700 ÷ 800 mm, in comparing with the height of some normal equipment (buffer tower, salver, bubble up...), the height of this equipment is so lower and the dependence of productivity on the height is not unnoticeably.

5. All of recurrent equations in data processing methods both Excel and SPSS for Window also have same form; all coefficient in the equations is rather equal, especially recurrent coefficient R^2 gets 0.98 ÷ 0,99 value. So, the result is acceptable completely with very high confidence. These equations let us choose and design equipment advantageously and easily.

6. If we use the equipment only for dust treatment or waste air mixed dust and poisonous gas at low concentration, we no need to use equipment for dew making by the above pulse making principle.

7. In case poisonous gas concentration in mixed dust and poisonous gas is low, we just need use water solvent. This shows their economy - rather low operating cost. In case of high poisonous gas concentration, dust in mixed stream has high chemical and physical activation, choosing suitable solvent is very necessary and at that time we need to install dew making equipment according to stroke principle as we mentioned above.

8. Pressure loss that is about 80 mmH_2O to 100 mmH_2O maximum is so lower than comparing to other equipment in the same condition. Therefore, electrical capacity spending is too lower than other equipment (5.5 HP comparing with 7.5HP).

9. Maximum noise of the equipment is 87 dBA and the minimum is 76.6 dBA. These numbers are much lower than allowing standard in factory (following Vietnam Standard – TCVN.1995 – Noise in factory is 90dBA).

External experiment for poisonous gas

Equipment was experimented on discharged smoke from FO burning which has 3% sulfur content of their weight, solvent is water with flow coefficient vary from 0,308 l/m^3 to 0,836 l/m^3 air. Oil was heated until 90 ^{0}C then pushed into combustion chamber by ejector. Discharged gas was cooled until 350 ^{0}C. SO_2 treatment productivity showed on the following figure 1.4:

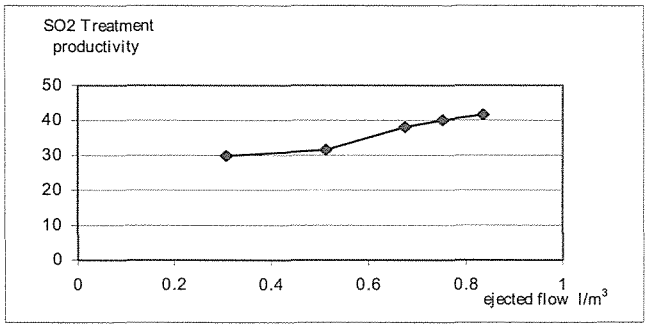

Figure 1.4. SO_2 treatment productivity in discharged gas of oil combustion

From the above experimental results let the author give some following remarks:

1. Productivity of the equipment fluctuates from 29,52% ÷ 41,50% for SO_2, meanwhile in the same condition buffer tower and bubble up just reach to 15 ÷ 20 %.

2. Sprayed coefficient μ = 0,5 l/m^3 ÷ 0,8 lít/m^3 is rather appropriate. Comparing to ceiling gas washing tower which has sprayed coefficient μ = 0,5 l/m^3 ÷ 8 l/m^3 discharged gas in this case has lower water-current but higher productivity.

3. Choosing water as solvent to text shows the productivity of the equipment increases 1.5 ÷ 2 times and the equipment works stably. Although output discharged gas is still higher than discharged gas standard (B level standard. TCVN. 5939.1995) But if we use alkali as solvent the equipment will get higher treatment efficiency and guarantee SO_2 concentration lower than 500 mg/m^3 after getting out the equipment (B level standard. TCVN. 5939.1995).

4. Loss of total system from 110 to 115 is lower than which of buffer tower 180 ÷ 250mmH_2O in the same condition. Thus is show that spent electrical capacity is smaller.

5. The equipment can overcome some phenomenon such as choking, obstructing equipment.

Conclusions

1. Wet filter methods using for dust and poisonous gas treatment applied in Vietnam show that in Vietnam condition certainly they have some disadvantages due to essence of discharged gas carrying particular characteristics of small and medium industry, backward industry, mixed raw materials, reprocessing or salvaging.

2. Applying effect of whirling air stream to build centripetal dust wet-filter principle allows to concentrate dust in center of the equipment by centripetal force of whirling stream, combining with dew making technology by clashing pulse also allows to build a new wet-filter principle – ***wet-filter principle***. This can be considered as the seventh wet-filter principle after 6 current wet-filter methods.

3. Centripetal wet-filter equipment has so many advantages: high productivity, low cost, simple operation, low operating cost, avoiding choking and obstructing phenomena that other equipment may get. Especially, the equipment works so stably even when discharged gas has high temperature and its components include dust and poisonous gas.

4. Studying results on practical model that is very common in countries which have small and medium industry like Vietnam, show that applying ability of the equipment is not only in Vietnam but also in other countries having the same condition.

5. The built curves from experiment allow to design and choose wet-filter equipment according to centripetal wet-filter principle is rather simple and easy.

6. External studying results for poisonous gas show that in case the solvent is water, SO_2 treatment efficiency in discharged gas of oil combustion increases 1.5 or 2 times in comparing to other equipment. It proves that the equipment has higher productivity than other equipment. If the solvent is limewater or alkali, the efficiency will increase so much and output discharged gas will have lower concentration in 7 comparing to TCVN.1995.

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