Configuration Comparison of Municipal Waste Incineration Plant in County Area of Henan Province

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Abstract. Based on the status of county-level domestic waste treatment in Henan Province, this paper compares the system configuration, land occupation, technical parameters, operational flexibility and initial investment for 1×600t/d and 2×300t/d incineration lines and recommendations are proposed in the end. A single incineration line has a lower initial investment, and is suggested on the premise that temporary waste transfer and storage space can be reserved. Otherwise double incineration lines should be used for operation flexibility.

1. Introduction
With the development of Chinese society and improvement of present living situation, the landfill storage volume is close to designed capacity, which cannot deal with the existing urban waste. Waste incineration power generation, with obvious quantity and volume reduction as well as no long-term storage requirement, is an effective means for the thorough and rapid disposal of municipal solid waste and provides a good solution for the resource utilization [1]. Municipal solid waste incineration power generation is the main method of domestic garbage treatment in county area, and is an important measure for urban ecological environmental protection.

According to economy level in Henan Province, the per capita daily waste generation in the central urban area is 1.2 kg with a collection rate of 100%, while the county area per capita daily waste generation is 0.5 kg with collection rate of 60%. Based on the of permanent residents and floating population, solid waste per town is expected to reach 500t / d to 600t / d by 2025 in most of county-level cities. Therefore, the design scale of most county-level cities is determined to be 600 tons of domestic waste incinerated per day, which is the solid waste incineration plant capacity studied in this paper.

2. Options of 600t/d municipal solid waste incineration plant

2.1. Principles of incineration lines configuration
In accordance with the provisions of the Technical Code for Projects of Municipal Solid Waste Incineration (CJJ90-2009) and the practical experience of domestic and international waste incineration plants, the number and scale of incineration lines should be based on the technology of the total plant waste disposal quantity and the type of furnace selected, complied with which 2 to 4 incineration lines are recommended.
However, the philosophy of this principles is based on the following premises:
(1) Minimum investment and operating costs;
(2) Minimum downtime loss;
(3) Mature operating experience;
(4) Multiple equipment choices in the market;
(5) Storage capacity of garbage pit in case of shutdown during failure.
In that case, it is necessary to compare one single incineration line (1x600t/d) with 2 lines (2x300t/d) at the same total output.

2.2. Waste components and calorific value
The calorific value at the design point is related to the operating efficiency and operating cost throughout the life of the incineration plant [2]. With a high design calorific value, the quantity of solid waste been disposed per day shall decrease, which leads to huge waste storage problem for the serviced areas. Otherwise, a low design point means low thermal load for furnaces at a long time, which leads to high operation and maintenance costs.

Table 1. Typical domestic waste composition.

| Items          | Organic | Inorganic | Recyclable waste |
|----------------|---------|-----------|------------------|
|                | Vegetative | Animal           | Others           | Cinders | Ash & Earth | Tile & Others | Fabric | Plastics | Glass | Metals | Others |
| Composition    | 31.5    | 10.2      | 0.5            | 35.6    | 2.5         | 5.0          | 5       | 4.6      | 0.8   | 1.2     | 1.4    | 0.7    | 1.0    |
| Ratio (%)      | 42.2    | 48.1      |                |         |             |              |         |          |       |         |        |        |        |

Considering the development and improvement of present living situation of Henan province, the design low heat value (LHV) of is determined to be 6500kJ / kg (1555kcal / kg). To ensure the stable operation of the incinerator in a wide range of garbage calorific value, the applicable LHV range is between 4600kJ / kg (1000kcal / kg) and 8400kJ / kg (2010kcal / kg).

2.3. System configuration for 2 options
Option A: The main equipment is 1 × 600t / d incinerator + 1 × 12MW medium temperature, medium pressure single shaft condensing steam turbine generator + 1 set of flue gas disposal treatment. Mechanical grate furnace and horizontal heat recovery boiler are equipped for the comparison.
Option B: The main equipment is 2 × 300t / d incinerator + 1 × 12MW medium temperature, medium pressure single shaft condensing turbine generator+ 2 sets of flue gas disposal treatments. Mechanical grate furnace and vertical heat recovery boiler are equipped for the comparison.

The comparison is based on the following premises:
(1) The progress of flue gas treatment is selective non-catalytic reduction method (SNCR) denitration + semi-dry FGD + dry FGD + activated carbon adsorption + bag filter, both for option A and 2, but with different capacities.
(2) The steam parameter at super heater outlet is 4.0MPa, 400°C with feed water temperature of 130°C for both option A and option B.
(3) The flue gas temperature at heat recovery boiler outlet is 210°C.
(4) The type N12-3.85/390, medium temperature, medium pressure single shaft condensing steam turbine generator is used in both option A and option B.

3. Comparisons of 2 Options
3.1. General and Equipment Comparison
Table 2 shows the general difference between 2 options.
Table 2. General Comparison of 2 Options

| NO. | Item                             | Option A                      | Option B                      |
|-----|---------------------------------|-------------------------------|-------------------------------|
| 1   | Boiler                          | 1×600t/d                      | 2×300t/d                      |
| 2   | Daily disposal                  | 600 t/d                       | 600 t/d                       |
| 3   | Flue gas treatment sets         | 1                             | 2                             |
| 4   | Operation mode                  | 1 Unit                        | 2 Units                       |
| 5   | Thermal efficiency              | High                          | Low                           |
| 6   | Main power building land area (m²) | 4817                          | 6474                          |
| 7   | Operation Flexibility           | Low, Shut down the plant in maintenance | High, 1 in operation and 1 in maintenance |
| 8   | Maintenance & Management Cost   | Low                           | High                          |

For option A, one primary fan, one secondary fan, one furnace wall cooling fan, and two feed water pumps (one in operation and one in standby), 1 set of flue gas treatment device (including 1 set of induced draft fan), 1 set of flue gas online continuous monitoring system, one stack with one flue are designed for the incineration plant.

For option B, two primary fans, two secondary fans, two furnace wall cooling fans, two boiler feed water pumps common for 2 units, 2 sets of flue gas treatment devices (including two induced draft fans), 2 sets of flue gas online continuous monitoring system, and 2 flues shared in one stack are designed for the incineration plant.

Please refer to Table 3 for detailed parameter of main and auxiliary equipment.

Table 3. Main & Auxiliary Equipment Parameter

| NO. | Item                             | Option A                      | Option B                      |
|-----|---------------------------------|-------------------------------|-------------------------------|
| 1   | Boiler Capacity                 | 1×600t/d                      | 2×300t/d                      |
| 2   | Primary Air Fan                 | 1 set, 78648Nm³/h, 7020Pa    | 2 set, 58000Nm³/h, 4920Pa    |
|     |                                 | 1×240kW                       | 2×160kW                       |
| 3   | Secondary Air Fan               | 1 set, 32124Nm³/h, 8268Pa    | 2 set, 11000Nm³/h, 7080Pa    |
|     |                                 | 1×115kW                       | 2×60kW                        |
| 4   | Furnace Wall Cooling Fan        | 1 set, 10350Nm³/h, 3312Pa    | 2 set, 5180Nm³/h, 3120Pa     |
|     |                                 | 1×20kW                        | 2×11kW                        |
| 5   | Stack                           | 1×φ2.8m×80m (Height)         | 2×φ1.6m×80m (Height)         |

3.2. Land Area Comparison

The water treatment equipment, main electrical equipment, and common systems of the two options of flue gas treatments, such as limestone slurry system, lime storage system, steam turbine equipment occupy almost the same area. In the land areas comparison of the two options, only boiler room and the flue gas purification system are mainly involved.

For option A, a 12MW steam turbine generator and one incinerator line as well as one set of flue gas treatment device, are equipped, which takes up 4817 m² for boiler room and flue gas treatment system. While for option B two incineration lines with a 12MW steam turbine generator, the boiler room and flue gas treatment system cover an area of 6474 m².

3.3. Initial Investment Comparison

Since the steam generator, water treatment equipment, electrical equipment, control equipment and common facilities of flue gas treatment system in the whole plant are basically the same in both options, the investment comparison excludes equipment purchase and installation costs of the above equipment, and mainly focus on the differences in the remain part. The initial investment mainly includes equipment...
costs, installation costs, construction costs [3], etc. The specific calculation results are shown in Table 4.

### Table 4. Initial Investment Comparison.

| NO. | Item                                              | Unit(Yuan) | 1×600t/d | 2×300t/d |
|-----|---------------------------------------------------|------------|----------|----------|
| 1   | Incinerator and Heat Recovery Boiler               | million    | 91.63    | 124.93   |
| 1.1 | Equipment Costs                                   | million    | 37.67    | 46.27    |
| 1.1.1| Incinerator                                       | million    | 16       | 9.50×2   |
| 1.1.2| Heat Recovery Boiler                              | million    | 20.50    | 12.80×2  |
| 1.1.3| Boiler Auxiliary Equipment                         | million    | 0.13     | 0.19     |
| 1.1.4| Fans(Include IDF)                                 | million    | 0.88     | 1.25     |
| 1.1.5| Leachate Recycle System                           | million    | 0.16     | 0.23     |
| 1.2  | Installation Costs                                | million    | 6.75     | 8.43     |
| 1.2.1| Incinerator                                       | million    | 2.06     | 2.57     |
| 1.2.2| Heat Recovery Boiler                              | million    | 3.15     | 3.94     |
| 1.2.3| Boiler Auxiliary Equipment                         | million    | 0.04     | 0.05     |
| 1.2.4| Fans(Include IDF)                                 | million    | 0.15     | 0.18     |
| 1.2.5| Leachate Recycle System                           | million    | 0.05     | 0.06     |
| 1.2.6| Air Duct and Flue Gas Duct                        | million    | 1.30     | 1.63     |
| 1.3  | Construction cost                                 | million    | 47.21    | 70.23    |
| 1.3.1| Main Power Building(Exclude solid waste pit)      | million    | 44.09    | 67.11    |
| 1.3.1.1| Volume of Main Power Building                     | m³        | 179964   | 273922   |
| 1.3.1.2| Volume unit price index                           | m³/Yuan   | 245^{(1)}| 245^{(1)}|
| 1.3.2| Solid Waste Pit                                   | million    | 3.12     | 3.12     |
| 1.3.2.1| Volume of Solid Waste Pit                         | m³        | 5376     | 5376     |
| 1.3.2.2| Volume unit price index                           | m³/Yuan   | 580^{(2)}| 580^{(2)}|
| 2    | Flue Gas Treatment System                         | million    | 16.40    | 20.91    |
| 2.1  | Equipment Costs                                   | million    | 13       | 16.65    |
| 2.1.1| Bag house                                         | million    | 5.50     | 7.05     |
| 2.1.2| Semi-dry FGD                                      | million    | 5.70     | 7.33     |
| 2.1.3| Hydrated Lime Injection System                    | million    | 0.30     | 0.40     |
| 2.1.4| Lime slurry preparation system                    | million    | 0.50     | 0.66     |
| 2.1.5| Activated Carbon Injection System                 | million    | 0.25     | 0.30     |
| 2.1.6| SNCR devices                                     | million    | 0.75     | 0.91     |
| 2.2  | Installation Costs                                | million    | 2.30     | 2.84     |
| 2.2.1| Bag house                                         | million    | 0.53     | 0.63     |
| 2.2.2| Semi-dry FGD                                      | million    | 1.30     | 1.64     |
| 2.2.3| Hydrated Lime Injection System                    | million    | 0.10     | 0.12     |
| 2.2.4| Lime slurry preparation system                    | million    | 0.26     | 0.32     |
| 2.2.5| Activated Carbon Injection System                 | million    | 0.08     | 0.09     |
| 2.2.6| SNCR devices                                     | million    | 0.03     | 0.04     |
| 2.3  | Construction cost                                 | million    | 1.10     | 1.42     |
| 3    | Solid Waste Feeding System                        | million    | 2.97     | 5.94     |
| 3.1  | Equipment Costs^{(3)}                             | million    | 2.93     | 5.86     |
| 3.2  | Installation Costs                                | million    | 0.04     | 0.08     |
| 4    | CEMS                                              | million    | 1.01     | 2.02     |
| 5    | Stack                                             | million    | 3.62     | 4.80     |
| 6    | Sum of Initial Investment                         | million    | 115.63   | 158.60   |
| 7    | Investment Balance                                | million    | -42.97   | Benchmark|

Note: (1) and (2) are estimated from the construction cost of the established waste power plant. (3) Specially, one garbage grab is equipped for option A while two for option B.
3.4. Comparison of Operating Flexibility

More incineration lines bring out smaller impact of equipment failures and maintenance on the incineration plant, and contribute to the stability of the steam turbine operating conditions [4]. Therefore, there is higher operational stability for $2 \times 300\text{t/d}$ than $1 \times 600\text{t/d}$. Once an unscheduled stop or overhaul happens, one single incineration line will lose all its waste disposal capacity while incineration lines more than one could keep one line in maintenance and the other in over-loading mode as 110%. In addition to the solid waste pit with the storage volume of 10 days, the waste disposal won’t be affected.

4. Conclusion

Technically, both options are feasible. Option A, due to its larger capacity, relatively higher thermal efficiency, a smaller land area, fewer maintenance, costs less than option B in the initial investment by 42.97 million yuan according to Table 4. But the inflexible plant maintenance shall also be considered. In summary, if there are determined garbage transfer plans or temporary landfill to storage the solid waste during overhaul and accidental shutdown period, $1 \times 600\text{t/d}$ is recommended. Otherwise $2 \times 300\text{t/d}$ shall be adopted although with a higher initial investment.

References

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