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Incineration technologies for various waste conditions

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Abstract. Waste to Energy is one of the solutions for the waste management widely used in the world. Since the Waste to Energy plant is an important infrastructure for local waste management, it should be reliable. To realize the reliability of the plant, it is necessary to choose and apply appropriate technologies in accordance with waste condition. Waste condition, like mass flow, heat value and compositions, varies widely depending on the local characteristics, waste management system, economical status, population, life style and so on. Waste to Energy technical should adapt to such variation. Steinmüller moving forward grate owned by Steinmüller Babcock Environment GmbH (SBENG) and Nippon Steel & Sumikin Engineering Co., Ltd. (NSENGI) has been developed as high-efficient waste to energy technologies with approximately 500 reference plants and long-time experience. The history had started from Europe, and it has been extended to all over the world including Asia. Nowadays, more opportunities can be seen in Asia. This paper introduces technical measures and application criteria for various waste conditions. Modification of the length and width of grate system can cover various scales of waste flow. For the variation of waste property and compositions, it is corresponded by means of grate cooling system, combustion chamber design, combustion air condition and other related technologies. These technologies can be the solutions for Asian waste conditions. Appropriate combination of these technologies can contribute for the development of waste to energy in Asia.

1. Introduction

Combustion and boiler engineering have been improved enormously, especially during the past 15 to 20 years, based on growing knowledge, increased requirements and improved production possibilities. The following is a description of the current state of the art and technology.

With regard to the incineration of waste, the reliable and eco-friendly disposal of the delivered waste material has been the sole concern for a long period of time. Today the efficient utilization of the energy contained in the waste is gaining growing importance because of the question of suitable energy carries and CO_2 problems- as about 50% of the waste is of biological origin and, therefore, is climate-neutral when incinerated. The continuously increasing demands on the plants are asking for the careful planning of the process chain. Exemplarily, a longitudinal section of an overall plant is shown in figure 1. The most important sections are the firing system with grate, the steam generator (boiler) and the flue gas cleaning system. Not shown here is the energy generating section, which is also part of the overall plant. The steam which is generated in the boiler is delivered to a turbine and used there for electricity generation or the energy is used for district heating. A combination of both systems is also common.

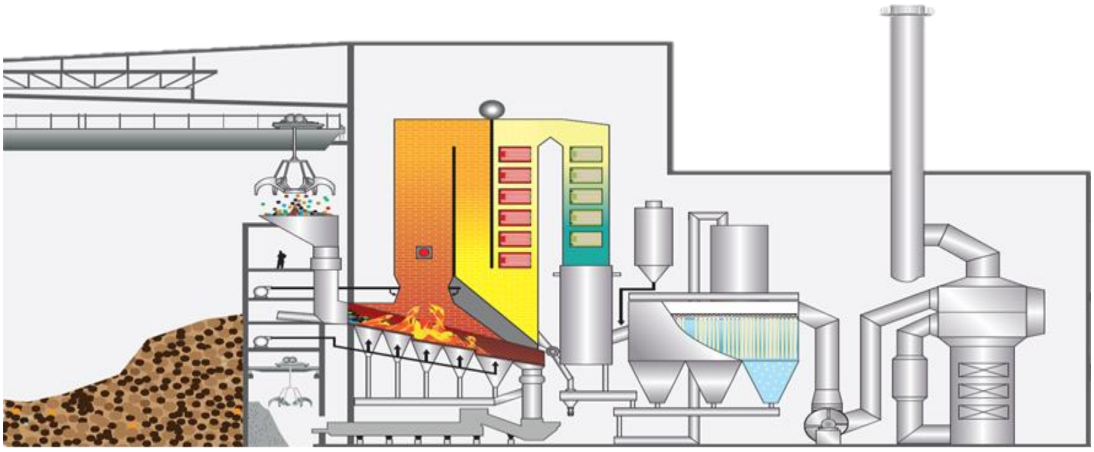

Figure 1. Incineration plant longitudinal section.

The core of any waste incineration plant is the firing system with the moving grate. Figure 2 is showing Steinmüller moving forward grate system including the waste feeding chute, the feeder and the actual grate which, in this case, is of 2-track design. The grate is slightly inclined for optimizing waste movement and, as a peculiarity, has 2 steps. The first step is positioned in the main combustion area between 2nd and 3rd grate zone. By means of this, larger waste particles are broken up and the waste is overturned in order to intensify the combustion process. The second step is positioned behind the 4th zone and breaks up any possibly existing slag agglomerations. This novel grate design contributes to a substantial improvement of burnout and, thereby, to optimized slag quality.

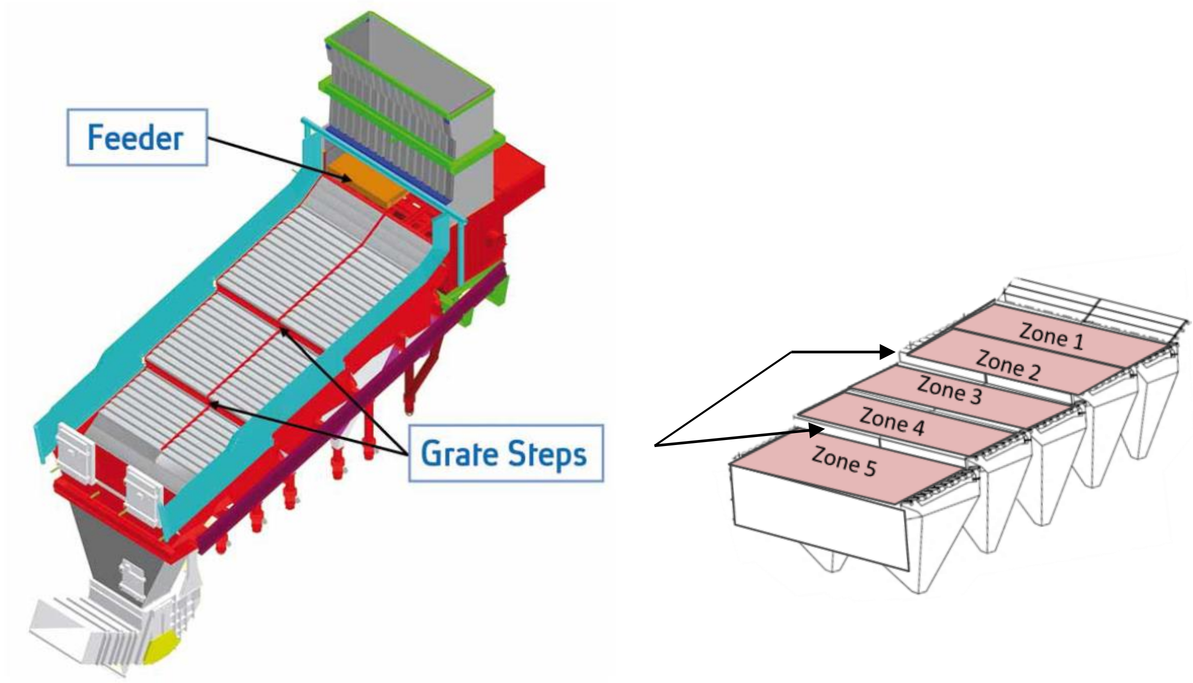

Figure 2. Firing grate system with two tracks.

In the course of time the grate has been optimized continuously and adapted to the current requirements. In this development, the basic concept has not been changed during the recent decades because of the good experience made and the robust and sturdy construction. Part of the installation is in particular the grate carriage, see figure 3, with which every second grate row can be moved for transporting the waste. These grate rows continuously forward and in reverse with a velocity which is governed output-related by the combustion control system. The movement of the grate carriage is effected by means of a hydraulic drive, arranged at the grate center. By means of a mechanical device, the so called rocker shaft, the grate carriage is on both sides forced to maintain an absolutely parallel movement. Therefore, any electronic control, which could fail, is not required.

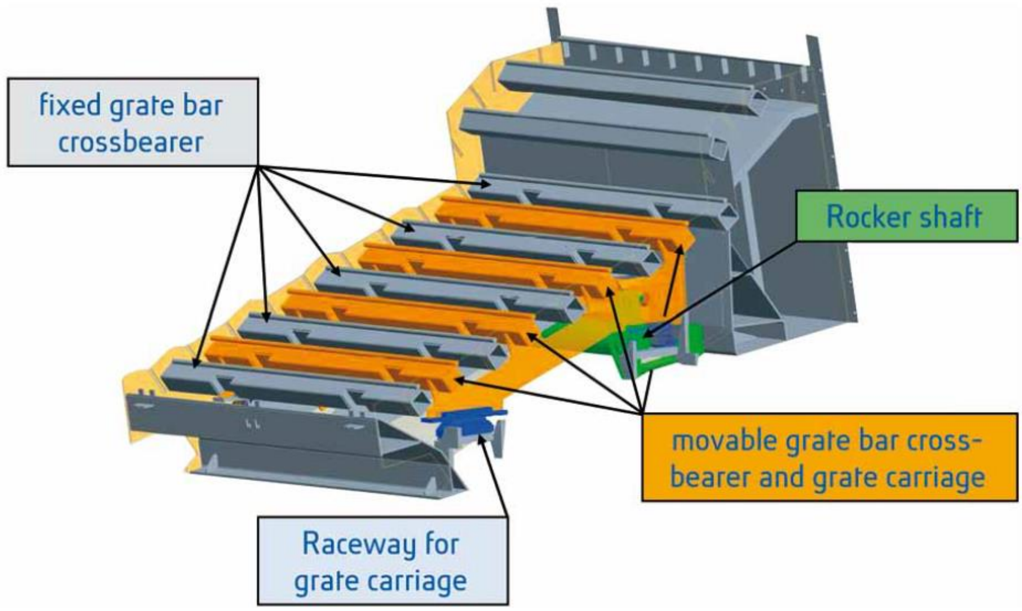

Figure 3. Grate module and grate movement.

2. Technologies for waste mass flow and thermal load variation

Because of the modular design of the grate, allowing modifying the length and width of the individual modules, the grate can be adapted very well to the various operation capacity and existing heat values. The grate width of a track ranges from 2.25 m to 3.55 m. If these dimensions should not be sufficient it is possible to arrange several grate track parallel to each other. New to our portfolio is that the grate can be composed of up to 4 tracks (figure 4). In this way, a grate width of maximum 14.35 m can be implemented. Accordingly the thermal load can range from approximately 10MW up to 160MW and the operation capacity can range from approximately 2t/h (48t/d) up to 50t/h (1,200t/d). As a reference, we have 40t/h (960t/d) plant which is operating and 45t/h (1,080t/d) plant which is under construction. The illustration is showing the relationship between the number of grate tracks and the respective maximum grate width.

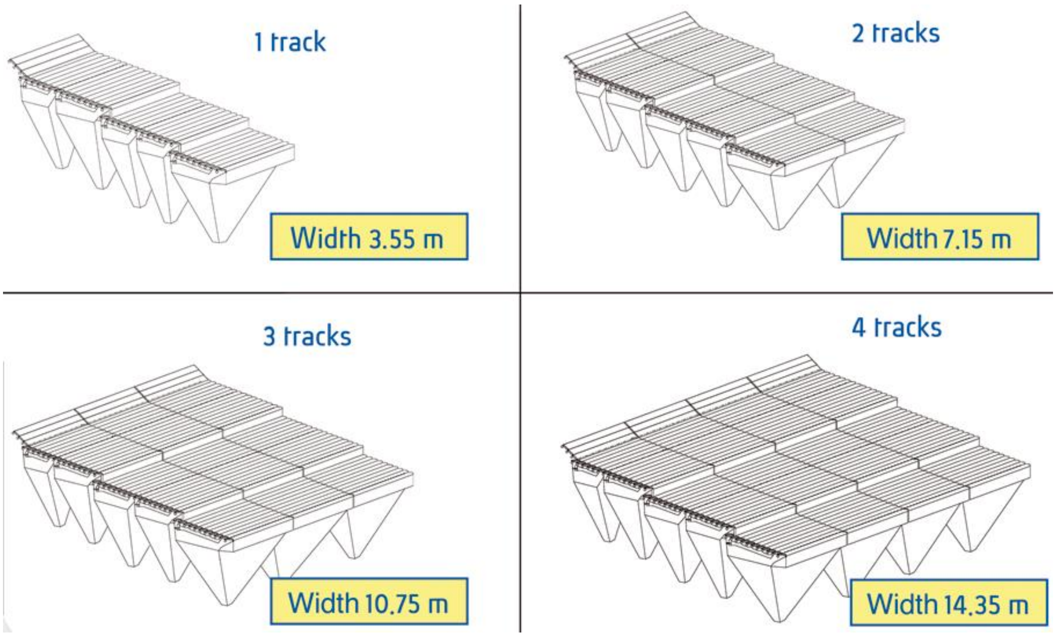

Figure 4. Maximum width of grates.

3. Technologies for waste components variation

3.1. Technologies for low heat value and high moisture content waste

Waste property such as heat value, components, and etc. is important for incineration technology. In Asia, there is the concern about low heat value and high moisture contents in the waste. Steinmüller moving forward grate technology has the special features with the grate system and furnace concept for burning the waste with a low heating value and high moisture content.

3.1.1. Grate module arrangement. Basic grate module arrangement can treat various kinds of waste. Grate module has steps to stir the waste. First step, which is positioned after Zone 2, can mix waste and put unburning waste on the surface. Because of this, combustion condition becomes more uniform than without steps. Second step, positioned after Zone 4, mixes the waste again and put the waste which remains unburnt on the surface to complete the waste combustion. In the case that the moisture content of waste is high, grate module arrangement would be optimized and design of grate system is to be sophisticated. For instance, Grate module length is extended for higher drying performance. Because of this, stable combustion is achieved and excellent residence time is secured. At the same time, optimizing primary air supply flow and each grate speed can be tuned appropriately according to waste conditions. Grate step arrangement for high moisture content waste is optimized by means of adjusting step position and number of steps. Because of this, efficient drying and mixing waste is achieved at main combustion zone. Furthermore, dehydration can be done at feeder outlet to discharge leachate which is coming from high moisture content waste, as an additional option. Because of grate module system which can easily arrange grate combination, Steinmüller grate system has advantages to be able to treat various kinds of waste.

3.1.2. Air preheating system. Primary air preheating is adapted for various ranges of heat value of waste to achieve could be sufficient drying at grate drying zone. With low heat value and high moisture content waste, increasing preheating temperature can improve drying performance. Because of this measure, stable combustion condition at main combustion zone can be maintained. Secondary Air preheating is also effective for keeping secondary combustion temperature stable and it is important to maintain the combustion temperature over 850°C and residence time more than 2 sec for decomposing DXNs.

Figure 5 shows the simulation model for evaluating the effect of primary air preheating. Theoretical calculation is carried out using this model how the required time for drying depends on the preheating temperature of the primary air when treating waste with 60% moisture content. In this calculation, required time for drying is to be normalized when temperature of primary air is 40℃, this temperature means no preheating. The result of this calculation (figure 6) indicates that primary air preheating is effective to shorten the drying time. In case preheating temperature of the primary air is 120℃, it can be completed drying in one tenth of the time compared with no preheating. Getting preheating temperature higher, required time of drying generally become shorter. According to these studies, it is shown that increasing the preheating temperature of primary air is effective for treating high moisture content waste.

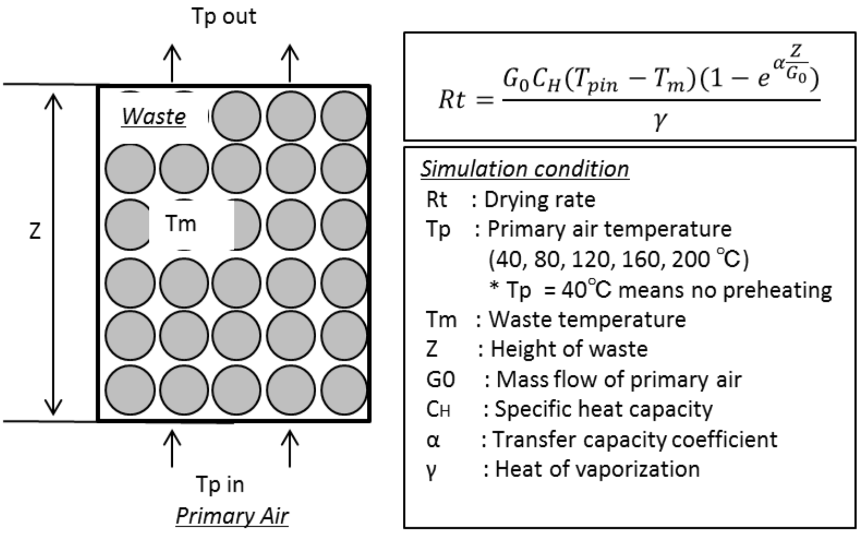

Figure 5. Simulation model for evaluating the effect of primary air preheating.

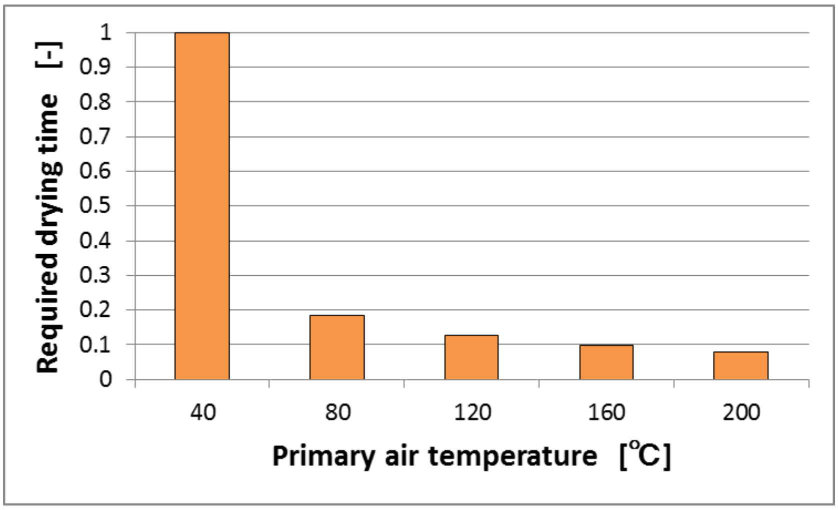

Figure 6. Simulation result of required drying time.

3.1.3. Combustion chamber. With low heat value waste, adiabatic combustion chamber with brick is applied to maintain appropriate combustion temperature. To prevent clinker formation, partial adaption of water cooled wall structure is effective in this case. In the case of heat value of the waste ranged between low and middle, the structure which consists consist of boiler membrane wall with lower heat conductivity refractory, that is high alumina basis refractory, can be the solution to improve the combustion condition. With the low heat conductivity refractory, temperature drop inside combustion chamber can be suppressed, and the combustion condition becomes optimized.

The case study to evaluate the flue gas temperature after 2sec at combustion chamber with the different waste heat value and different combustion chamber structure is carried out. This case study is calculated under the condition that heat value is 3cases and combustion chamber design is 3cases under the fixed conditions of waste mass flow, process values and boiler dimensions. Figure 7 indicates the optimum combustion chamber structure depending on the heat value of the waste. In the case of low heat value waste (1,500kcal/kg), when SiC refractory is adapted, flue gas temperature become below 850℃ which there is concern about DXNs formation. On the other hand, high alumina refractory and brick achieves sufficiently high temperature to decompose DXNs. High alumina refractory, brick or the combinations can be the best solution for low heat value waste. With middle heat value waste (2,000kcal/kg), any structure can achieve sufficiently high temperature to decompose DXNs. However when brick is adapted, flue gas temperature become around 1,050℃ which lead to a concern about clinker formation. SiC, High alumina based or the combination are optimized the combustion chamber structure in this case.

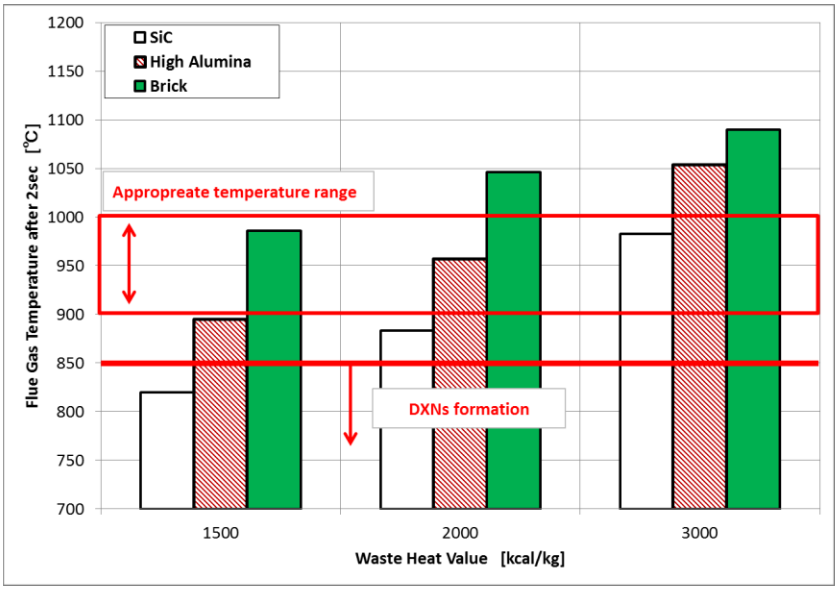

Figure 7. Case study results of combustion condition.

3.2. Technologies for high heat value waste

3.2.1. Combustion chamber. With middle to high heat value waste, boiler membrane wall with higher heat conductivity refractory, which is SiC basis refractory, is adapted. SiC basis refractory can prevent the combustion chamber from reaching a high temperature because SiC basis refractory can maintain high heat transfer performance. If the thermal load at boiler is too high, protection by cladding to get higher heat transfer performance than refractory can be applied. Protection by cladding is also effective to enhance cooling performance at side wall and prevent boiler heat transfer surface from clinker formation. As an example with middle to high heat value waste in the case of Europe, SiC tiles, backfilled or air ventilated, are commonly used for a maintenance advantage. This tile solution can be an alternative depending on material availability and operator's needs.

The result of figure 7 indicates the flue gas temperature after 2sec at combustion chamber with high heat value waste (3,000kcal/kg). High alumina and brick have clinker formation risk because flue gas temperature become more than 1,050℃. SiC is the best structure among SiC, high alumina and brick when waste heat value is high.

3.2.2. Grate bar cooling system. With low to medium heat values of the waste, air-cooled grate bars are used as grate surface (figure 8). The grate bars are not connected to each other, however are moveable and placed at a defined distance for thermal expansion. From this kind of installation results a well distributed free cross section for the passage of the primary air and, because of this, uniform combustion. Installing the bars at a distance has also the advantage that the bars can move freely against each other and a self-cleaning effect is obtained. In addition, the grate bars can be replaced during standstill periods very easily and quickly if necessary. For higher heat values, for instance with RDF, water-cooled grate bars are used as grate surface (figure 9). These are somewhat wider than the air-cooled bars, but have in longitudinal direction the same length and contour. Therefore, the same substructure can be used and it is possible at any time, also subsequently, to replace air-cooled grate bars by water-cooled bars and vice versa. Depending on the respective level of the heat value, either only the main combustion areas, grate zones 2 and 3, or also additional areas are equipped with water-cooled grate bars. Based on the material selected, these grate bars have excellent emergency operation properties and can continue to operate, therefore, for more than one year without water cooling. Thus, it is not necessary to shut down the plant in case of problems with the cooling system.

Figure 8. Air cooled grate bars.

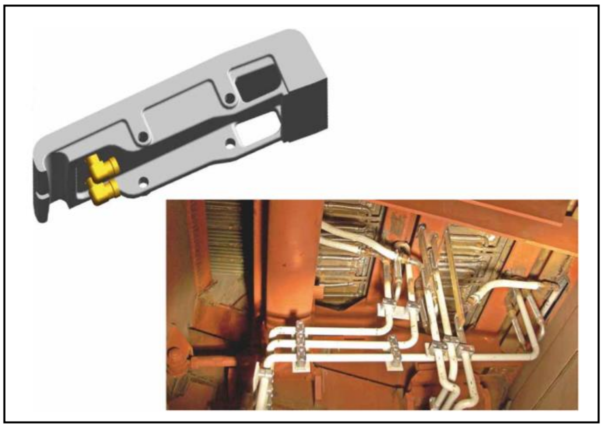

Figure 9. Water cooled grate bars.

4. Conclusion

This paper reported incineration technologies for various waste conditions, especially for Asia where waste has relatively low heating value and high moisture content. Development of these technologies, such as grate arrangement, combustion chamber, air preheating and grate bar cooling, have many experiences over decades, therefore it is well-developed and assures disposal of various kind of waste. These plants can be designed for operational capacities ranging from a 2t/h (48t/d) up to a through-put of 50t/h (1,200t/d). Also the heat value range from about 1,000 kcal/kg up to 4,000 kcal/kg.

As described by this paper, Steinmüller moving forward grate system can be adapted in an extremely flexible manner to predetermined boundary conditions and new statutory provision. In line with new knowledge gained from currently operated plants the development is continuously going forward. These technologies can be the solutions for Asian waste conditions. Appropriate combination of these technologies can contribute for the development of waste to energy in Asia.

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