Development of the Vee Grate system for Firing RDF – A Better EfW Solution.

DGA was formed by David Gardner during and after the Arbitration in which he together with other international experts defended Double A paper and went on to redesign the 2 Tampella BFB (Bubbling Fluid Bed) boilers to become successful units for Double A.

Gardner noticed that BFB systems were generally not popular in SE Asia due to the high parasitic loads, and the realisation that there was not a proven alternative, other than imported European grates, which were extremely expensive. So recalling that vibrating grates were popular in North America, DGA set about developing the Vee Grate which was intended to be manufactured wholly in Thailand.

DGA, already specialist in waste firing from European experience the Vee Grate was always intended to burn RDF fuel as well as the biomass that is commonly burned in Thailand. Raw waste as handled by the large push grates incinerators in use around the world was considered a declining market and too difficult for the Vee grate which is designed to burn prepared 'fuel'.

Previous experience of designing BFB units led DGA to adopt a number of features which set the Vee grate apart from other designs (see Product sheet for the Vee Grate). The result is a low cost locally made advanced firing device that is capable of high Availability and, of particular importance to the combustion engineer, is capable of stable suspension burning a wide range of high volatile solid fuels in a well-designed furnace. The stability is provided by a stable flame on the grate combined with the DGA designed secondary air array. This was originally developed for use on large BFB boilers, including the Double A boilers, and is now proven on 30+ Vee grate boilers installed in SE Asia.

Over the past 12 years the grate has improved in design and reliability so that DGA now market a boiler which uses a single Vee grate up to 60 tn/h capacity. To ensure availability matches typical twin grate boilers, the attributes of the system are high efficiency, high availability and considerable fuel flexibility.

The Vee grate follows a tradition of firing RDF which was inherited from the USA, where a Vibrating Grate was capable of firing RDF to replace coal many years ago. The Vee grate follows the same basic principles as the American unit but the designs are significantly different.

Biomass and RDF on the same design grate ?
The differences between RDF and Biomass are significant but manageable. First the Vee grate is designed to burn a fuel reduced in size to allow feeding by spreader stoker to the grate. If the fuel does not comply with the maximum fuel sizing criteria it will not pass through the spreader stoker and is unlikely to be fully burned on the Vee grate resulting in large unburned items passing to the bottom ash. This rules out burning raw waste but suits RDF firing.

Biomass is prepared to meet the handling criteria usually by shredding to meet the sizing criteria. The other important feature of biomass is the Moisture Content (MC) of the fuel as delivered and as stored. Biomass can be delivered to the boiler with up to 70% MC if the fuel store is not covered in the wet season. DGA work with their clients to produce an acceptable range of fuels from the available feed stock talking account of seasonal variations, including availability and MC of the fuels.

The range of biomass fuels currently handled by the Grate from dry rice husk to old wet bark means that the RDF fuels, which are a prepared fuel, will not cause any difficulty with the Vee Grate.

The factors which are potential problems with the RDF are:

1. the high plastic content which may melt and drip to the windbox,
   - the ignition system causes the fuel to light off as it drops to the top of the grate
   - grate bar operating temperature (c350 C) would cause ignition of plastics
   - high air DP on nozzles will cause even liquids to lift into the fire zone
   - so plastics are not an issue for the Vee grate

2. the lighter plastics may 'fly' in the above bed rising velocities
   - the Vee grate flames are up to 3m tall above the grate and the turbulence caused by high SA quantity will burn out the plastics and lighter fuel quickly
   - heavier particles will not rise

3. the acid content of the RDF which could cause corrosion on the grate.
   - the elevated temperature of the grate bars in operation is above the acid dew point so no corrosion concerns from condensing acid gases.

The remaining concerns with RDF burning are the boiler design which :-

- is provided under license from ERK Eckrohrkessel of Germany,
- ERK have designed more than 600 waste fired boilers

and the Gas Cleaning design, which will be by Luehr of Germany or equal ie from a proven source.

The Vee Grate shares similarities with the BFB system.
Gardner noticed when commissioning the first Vee grate, that the vibration caused the whole fuel bed to vibrate in a similar manner to the BFB system.

He also observed that the combustion process was substantially energized by the vibration, very similar to a BFB when fluidised. This increased the firing rate, presumably by causing the break away of the ash from the fuel allowing heat and air to the exposed surface of the fuel which enhances the combustion rate. The effect is very visible. (SEE video clip)

In BFB systems this effect is continuous which is why BFB s the champion in the combustion stakes but the similarities to the Vee grate make this a close second. The continuous vibration of a BFB system ensures that the fuel concentration in a BFB sand bed is no more than 4% by mass in the active bed. The rest is hot inert sand.

The Vee Grate is vibrated only intermittently, and as the coverage of the grate is 100% with ignited fuel so the potential heat release from the grate is very high, matching the heat release potential of a BFB with secondary air injection.

The Vee grate scores over the BFB system as it can handle larger fuel pieces once they have passed through the spreader stoker

Can the DGA system handle Raw MSW ?
The direct answer is No, but in many Asian countries DGA will offer an RDF manufacture and sorting plant which will take in the Raw Waste, segregate the Recyclable portion, separate the organic portion by size, segregate the metals by magnet and eddy current systems, separate the denser non combustibles in an air lifter and prepare the remaining fuel as RDF.

The last stage is to use an MBT (Mechanical Biological Treatment) system ie a composter to dry the wet organic rejects from c 70% MC to 25% MC which have been sized by the selection process and now makes a viable non odorous contaminated biomass fuel. This can be fired separately or co-fired with the RDF on the same Vee grate. This system has been offered extensively in Iran and in Malaysia.

Explain the differences between the push grates used on Mass Burn systems and the Vee grate

The Mass Burn system is in use around the world to provide a 'convenient' method of disposing of waste as it comes with only minimal sorting ie removing oversize material, without sending it to landfill. The convenience is that the waste is not pretreated before disposal.

The firing device, the push grate is designed for very long residence times, first to dry the fuel , then to ignite the fuel by boiling off the volatiles, leading to complete ignition of the fuel bed down to the grate bars and finally a long residence time on the grate to burn out the variable size waste fuel to eave low carbon ash. In other words the grate is designed to burn a low heat value fuel very slowly. Consequently the grates are very large and therefore expensive both to buy and to maintain.

The Vee grate as explained is designed to operate with waste treatment and conditioning as part of the 4Rs initiative. In order to handle the resultant 'fuels' the grates differ in their designs which are completely fuel dependent

These are the major differences:-

- The Push grate is up to 3 times the area of the Vee grate due to the lengthy residence requirement for the larger fuel particles. The Vee grate fires sized fuel and has more rapid ignition system.
- The push grate has a complex hydraulic mechanism to drive the many layers of grate bars. The Vee grate uses an simple electric motor driven eccentric to generate the vibration mechanism to a single component - the grate.
- The Push grate requires monitoring and adjustment to under grate air flows to maintain combustion performance. The Vee grate has a simple air distribution system which needs no adjustment.
- The push grate has many moving grate bars which wear one against the other causing a regular requirement for spare grate bars. The Vee grate has only one moving component and this exhibits very low wear, requiring hardly any spare parts to be replaced
- The push grate is made in exotic alloys to provide resistance to combustion temperature in its intimate contact with the fuel. The Vee grate is water cooled and so grate bars are manufactured in low cost allow steels and do not requite regular replacement.

The two styles of grate have each grown to suit a particular requirement. The Push grate can burn larger unsorted fuels, and the Vibrating grate can burn pretreated RDF and biomass fuels on a grate designed for high temperature combustion in a more compact furnace.

Landfill is now considered the least environmentally friendly method of waste disposal so the mass burn system is seen as environmentally clean and generally these systems are environmentally acceptable as they are fitted with sophisticated gas cleaning equipment, are proven and the waste is disposed of without any undue disturbance to the populace. The waste is fired 'as it comes' with minimal influence form the environmental lobby.

However in many countries waste can be very wet particularly if the area enjoys a monsoon or a wet season. Garbage can vary through the season with MC from circa 35% to 60+% in the wet season. Garbage at this level of moisture content does not burn easily and air preheat is necessary to ensure that the required gas temperatures in the boiler furnace are maintained. However the system is not an efficient system as no matter how much you preheat it you cannot burn water. If the waste is at 60% MC it may well require dry support fuel added or oil burners to be fired to sustain combustion to hold the required temperature which certainly detracts from the system efficiency.

The choice of which system fits depends on many factors from the available space, the need for a flashy showpiece, the weather, the desire to make more power etc etc

Does DGA have a system better than the 'Convenient' one in use today?
The DGA system is an extension of the original intent of the original Green incentives that caused the WTE revolution in Europe. This was the 4Rs system which required waste to be Reduced, Reused, Recycled or Recovered in that order.

The Valdemingomez Madrid WtE Plant was completed some 30 years ago and is still in operation today. It was at the time an innovative plant which follows the 4R incentive and is located at the Valdemingomez Environmental Park near Madrid City. This was designed by a team led by Gardner in his role as Head of Design for ABT GmbH.

The plant remains a model of compliance to the 4R incentive and it still follows the rules

- Reduce the waste quantity eg do not use or acquire unnecessary tools, equipment, food or consumables which are not required so end upin the waste stream.
- Reuse which means Reuse the item as is or restored to original function updating components as required ,
- Recycle, ie use the object or material to produce a new product from the recycled components or materials.
- Recover, the material and or the energy in the raw materials, this in our case proposes to burn the waste to recover as much as energy as economically possible, ie do not take the 'convenient' short cut as you can do better !
- *(Refer Valdemingomez_WTE.pdf).*

The Vee grate system fits into this concept as it is a comparatively low cost and low parasitic load version of the Fluidised bed system that ABT used at Madrid, as it uses similar features such energizing the combustion by vibration. It also burns pretreated fuel, fed by spreader stokers to the grate surface which allows operation with low excess air at maximum combustion efficiency. If the waste is delivered wet (c.>55%MC) then preparation should include drying of the fuel before combustion so that the combustion energy is not used to dry the fuel. Therefore the energy is used to for maximum steam production in the boiler and hence to produce the maximum useable electricity at the turbine.

What DGA offer is a part power station, part waste management plant, part fuel manufacturing plant which facilitates recycling of recyclable materials, but its most important function is to produce dry fuel to maximise the heat recovery and to reduce the inert left over residues to landfill, a reduction in the waste volume by c.95% of the original waste.

We can demonstrate that by drying the wet reject biomass waste the plant makes more energy from a known quantity of wet waste, than burning the wet waste direct. If we use a Bio-Dry process which accelerates the natural drying process (see presentations & diagrams), which is a very energy efficient process where we can reduce the MC of the fuel from say 70% MC to 25% MC in 3 weeks.

This process by drying the fuel allows up to 15% more power to be generated from the steam power plant, than the convenient mass burn system.

Together with the RDF separation plant this forms an MBT (Mechanical Bio Treatment) system. The process was first tested at the Madrid plant shown on the photograph. This was not the Bio-Dry plant but an earlier aerobic composting plant which successfully sold compost to Fruit growers in the region. Test firing of the compost showed a marked improvement in the BFB system used when handling dry fuel. The Bio-Dry is a modernised version of process.

The plant comprises the following major components to consume 1000 t/day of wet waste delivered to the intake station.

1. Waste Intake station with sorting by loaders
2. RDF preparation plant to produce the RDF fraction sized to the Eco plant requirement.
3. Bio Dry Fuel drying system to receive the reject 'biomass' wastes from RDF plant
4. fuel storage for RDF and dried biomass rejects.
5. 2 or 3 Eco Waste plants each to generate up to 60 tn/h superheat steam for the turbine station
6. 30 MWe Turbine plant with or without ACC dependent on water availability and cost.
7. Control and Electrical Package to provide control and emission monitoring
8. Civil Works

These are all shown on the BIO DRY presentation.

Conclusion

Waste to Energy has become a proven technology and a proven benefit to our over crowded world over the last 30 years. This is particularly the case in Europe where the popular Mass Burn technology has flourished as it produces an environmentally clean method of disposing of waste that requires little extra space for landfill and has little impact on the general populace. In other words it produces a 'Convenient' solution.

The Technology has developed along expected lines so 'convenient' solution to disposing of unwanted waste is that it is collected, held briefly at the disposal plant and then Incinerated with vey little sorting or pretreatment.

The equipment to provide this solution is now very reliable and these plants have very little impact on their surroundings other than the size of the building that houses the plant. But is this the most environmentally friendly method of disposing of the waste.?

Back in the 1990s Europe was going through the same process that faces Australia today. Which system is better ? The Europeans used the 4 Rs ie Reduce, Reuse, Recycle and Recover was preferred as a principle and a number of plants were built with this as the guide including the Madrid RIP (Refuse Incineration Plant) plant.

This was interpreted as :-

- Reduce is more of a national incentive which should govern our lives, and this should control ie reduce the amount of material entering the waste stream.
- Reuse, this goes against the consumer behaviour that drives our lives, but at Madrid they chose to Reuse the organic fraction by making compost which was destined for the fruit growers.
- Recycle was the next objective and the whole of the waste stream was passed through a MRF (Material Recycling Facility) where any item or materials that were economical suitable were removed and sent to a suitable recycling company who would prepare the material for resale or reuse.
- Recover. This is the area where a WTE plant should be used. The material that has been sorted and made into a Refuse Derived Fuel which
    - is dry as most of the moisture was removed with the organics,
    - has had potentially hazardous materials removed such as PVC with very high Chlorine content which is prime precursor for dioxins and acid gas
    - is sized as the firing system at Madrid was a bubbling fluid bed which requires sized fuel,
    - has had all the recyclable materials extracted which includes all metals, both ferrous and non ferrous,
    - has all bottles and glass separated which are available for recycling,
    - has all 'heavy inerts' such as stones and rocks removed by an 'air shifter'. These are available for recycling or disposal back to landfill .

- This leaves sized combustible dry fuel that is suitable for combustion on a more simple firing device such as a Vee grate as opposed to the Fluid Bed System as used at Madrid.
- There is an international market for RDF fuel which is used to fire many cement plants around the world and is increasingly being looked at as source of fuel for small sized power plants

DGA, whose principle was instrumental in the development of the Madrid plant, use the same 4Rs used as the guide back in 1990 and they have developed a firing system which is proposed to meet the requirement that does most to meet the Governments published requirements ie

- a safe and environmentally friendly system by burning as clean a fuel as possible
- by separating out potentially hazardous materials for separate disposal or sale
- and by preparing the waste to make a consistent fuel
- by producing approximately 15% more electricity from the same quantity of wet wastes than the mass burn systems available by drying the waste fuel

By working for Benedict Industries who are perhaps the best known private (family owned) waste handling company in NSW, Australia we are assured of an innovative and imaginative solution to the recycling and reuse proposed by the Australian Government National Waste Policy.

DGA merely add the final step in the Policy ie the Recovery for the available power at the highest practical level of efficiency.