Pictures: ESI Eurosilo B.V.

Fig. 1: Wood pellets are by far the most popular biomass fuel.

Storage of Biomass Fuel

Mammoth Silos for Handling large Amounts of Wood Pellets

Because of the growing amount of biomass to be handled in the coming years, there is an increasing interest in suitable high-volume storage solutions. Mammoth silos offer up 100 000 cubic metres capacity and also meet the safety and quality requirements.

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The worldwide usage of biomass fuel is considered to grow at an exceptional rate, due to environmental as well as economic concerns. Because of its organic origin, most types of biomass are regarded as a renewable and CO_2-neutral source. At the moment biomass is increasingly applied for co-firing and mono-firing power plants.

The most common practise is co-firing in pulverized coal firing plants, while the most popular biomass fuel by far, is wood pellets. As the use of wood pellets is expected to grow tenfold or more, the logistic solutions in the supply chain need to measure up to handling unprecedented volumes. Also the irregularities between production and demand will occur at a larger scale, causing transport and storage volumes to vastly increase.

The proper storage solution is determined by a number of key elements, such as capacity requirements, material characteristics, local circumstances, environmental regulations, safety and more.

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The EU Wood Pellet Market

The European wood pellet market shows a very exciting and promising development. Within the next decade, wood pellets will become a mainstream bio fuel in Europe. The EU 2020 targets for renewable energy sources and reduction of greenhouse gas (GHG) emissions are among the main drivers for this development. In 2009, approximately 650 pellet plants produced more than 10 million tonnes of pellets in Europe.

By 2020, the demand for wood pellets will range from 100 million tonnes up to

Table 1: Pellet properties compared to coal.

Properties	Wood pellets	Torrified pellets	Coal
Calorific value [GJ/m³]	10 to 11	18 to 21	27 to 30
Particle density [kg/m³]	1100 to 1900	1280 to 1360	1100 to 1800
Bulk density [kg/m³]	500 to 650	610 to 670	640 to 920
Moisture content [%]	8.0 to 11.2	3.9 to 4.1	15 to 65

140 million tonnes per year, based on market forecasts for pellets in the energy sector. This will have a serious impact on storage, handling and transport.

Torrified Wood Pellets

An upcoming innovation in the wood pellet market are torrified wood pellets. Torrefaction is a thermo-chemical treatment of biomass in the 280 to 340 degrees Celsius range. Compared to untreated biomass, regular wood pellets offer superior performance on all relevant characteristics, such as heating value, grindability, combustion nature, storage and transport and handling characteristics.

Compared to regular wood pellets however, torrified pellets contain substantially more calorific value (18 to 21 GJ/m³ versus 10 to 11 GJ/m³), due to a higher energy density and a higher mass density. Also handling characteristics like grindability are improved. Because of their black colour, the torrified wood pellets are also referred to as 'Bio Coal'. Conventional wood pellets are still most common, but the use of torrified pellets is expected to grow within the next years.

Storage and Handling

It is generally known that storing wood pellets involves risks of dust explosions. Dust built-up mostly occurs during the filling process of the storage facility. Therefore, the storage facility needs to be designed according to the Atex or similar local NFPA regulations.

The facility has to be equipped with safety equipment and the inner structure needs to be designed in such a way that the accumulation of dust on beams, rods, casings and other internal parts is prevented as much as possible.

Another vital aspect is to establish a conditioned environment in order to control the humidity. Keeping the wood pellets dry (moisture content below 15 per cent) ensures that the essential fuel characteristics are preserved and that the biomass is prevented from heating up (self heating).

These problems however will not occur with torrified wood pellets as these particles will behave in a much more inert way due to the thermal treatment.

Recently the physical properties of pellets have been determined by a number of experiments and tests at the Delft University of Technology [1]. The decisive properties are:

- angle of repose,
- particle density and bulk density,
- effective angle of internal friction,
- wall friction angle with polyethylen, concrete, mild and stainless steel, and
- attrition (wear of material).

Fig. 2: Typical torrified wood pellets.

Storing Pellets in a Eurosilo

Due to the increasing handling volumes various studies have been carried out to select the optimal storage system for storing pellets. Compared to covered stockpiles of circular domes, the Eurosilo system appears to be a feasible system for storage volumes up to 100 000 cubic metres per silo.

This large-scale silo system is a proven concept for storing coal and other bulk solids. The solutions that are used for material handling and fire protection can be applied for coal as well as for wood pellets. This means that such a silo designed for storing coal can be used for storing pellets as well after some minor modifications, and vice versa.

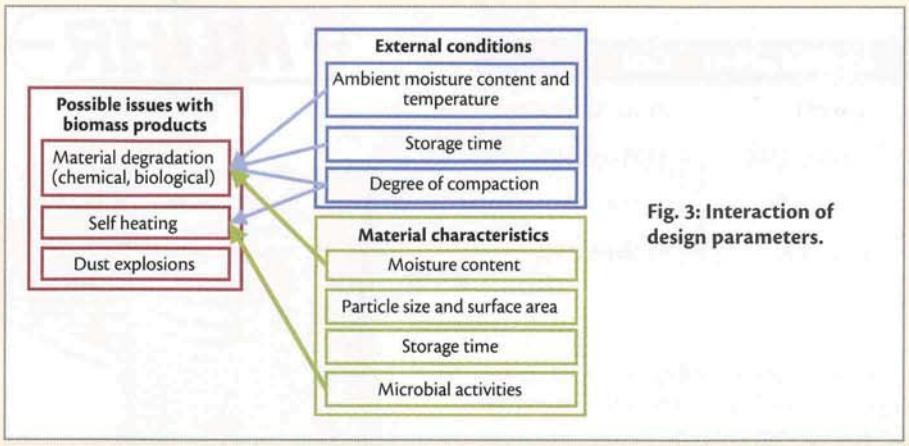

Fig. 3: Interaction of design parameters.

Comparing wood pellets and coal with regard to the design of a Eurosilo system, the following conclusions were made:

- The flowability of wood pellets is better than coal, so as far as the handling system is concerned, a coal silo is suitable for storing pellets.
- The moisture content of wood pellets is similar to high ranked coal (e.g. anthracite).
- Time consolidation is not an issue for torrified and relatively dry wood pellets.
- Attrition of wood pellets is very low on impact.

The Eurosilo system uses augers to transport the biomass to and from the centre of the silo. This way, the biomass is stored layer by layer and evenly spread by the auger system. By this movement the biomass is also homogenized.

Additional advantages resulting from the use of augers are that the silo can be easily emptied completely, and that due to the layer-by-layer filling and reclaiming, the loads are circular symmetric, which is the optimal load situation. Resulting in a simple straight-on cylindrical (slip) formed wall.

The silo system delineated here is fully automatically operated, which prevents operators from being present in a potentially hazardous environment. The pellets within the silo system are continuously monitored by the installed safety systems. In case the pellets should heat up, fire-fighting equipment, like foam/gel throwing and purging equipment is installed to resolve the situation.

First-in Last-Out

Inherent to the Eurosilo system is the first-in last-out system. Because of the low reactivity of dry wood pellets and the almost inert behaviour of torrified pellets this system is well suited for storing these fuel types in large volumes. A storage level of approx. 28 metres and a diameter of up to 70 metres will result in a storage volume of approx. 100 000 cubic metres.

For other types of biomass, like wood chips or poultry litter, which are more subject to deterioration, the storage time should be reduced and a first-in first-out system is preferred [2]. However, depending on the logistics, a twin silo system can reduce the storage period drastically by filling one silo and emptying the second one. Such a twin silo system also offers redundancy, which increases the availability of the logistic chain. By simultaneously reclaiming from two silos each blend can be prepared by using a controlled proportioning system.

Fig. 4: Typical layout of a Eurosilo for storing (wood) pellets.

Fuel Management System

Due to the high level of automation and the systematic loading and unloading of the Eurosilo's, the fuel logistics can be monitored and controlled. The fuel management system supports operators with supply planning and silo visualization solutions. The fuel management system is fully integrated within the silo control system.

Conclusion

The silo system described here meets the essential criteria for storing wood pellets in a safe and efficient way:

- keeping the stored material dry,
- minimizing the reaction with oxygen,
- allowing heat dissipation,
- enabling storage of high volumes with a minimal footprint,
- providing continuous monitoring of the wood pellet condition, and
- taking precautions for dust explosion.

Based upon Eurosilo's experience in coal storage and their research on handling wood pellets in cooperation with the Delft University of Technology in the Netherlands, we can conclude that storing wood pellets in a Mammoth silo system is among the most effective, safe and reliable solutions available. ■

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