

The contribution of AAC in securing a sustainable future. *AAC innovations from a life cycle perspective*

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Abstract: Lean manufacturing of AAC will be highlighted as a must in the modern building materials industry. Crises, lower building volume, overcapacity and calls for sustainability forced the industry to create with new application ideas, higher product quality, greater efficiency and lower manufacturing costs. A review of recent developments in technology and techniques will be presented and the green AAC plant heading to zero waste is introduced.

Keywords: AAC, Aircrete Europe, lean manufacturing, waste treatment, energy efficient production, smart building

1. INTRODUCTION

In the last decennia, several AAC factories have been built; most of them in China using Western Europe technology. The concepts were strongly technology driven and mostly based on the source and availability of raw materials and the demanded end-products. System suppliers achieved major innovations in the area of materials preparation and handling, automation, cutting techniques, reinforcement techniques, curing and energy management.

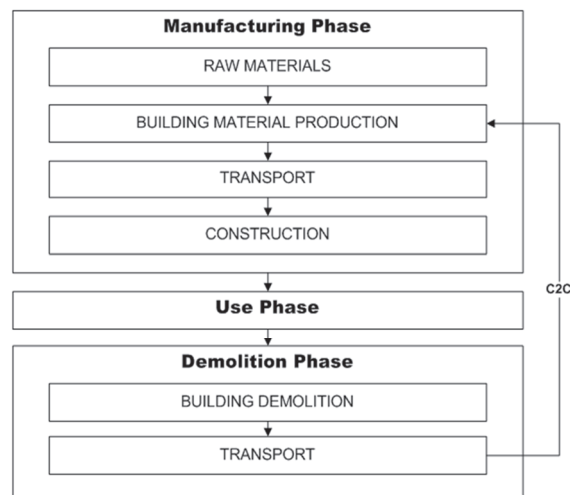


Fig. 1. The complete life cycle of building materials

The result is that recent AAC products can better compete with other building materials. On the product application and market development side however, there are still challenges to utilize the unique properties of AAC for smart building.

The hype of sustainable building is slowly but surely becoming practice. Urban planners, project developers, architects and most importantly, end users are becoming

more aware of the advantages of sustainable building. The life cycle perspective becomes the key focus in many design approaches for building developments. All the phases of a products life are taken into account when making decisions on building materials. Energy efficient and waste minimizing innovations in the manufacturing phase give AAC an advantage when compared to competing products. Furthermore, an application of the 'Cradle to Cradle' philosophy to the AAC life cycle can be easily made (Figure 1). If these advantages, together with the benefits of AAC in the use phase can be transferred to the decision makers in building projects, a major increase in market share can be obtained. Although this article focuses mainly on AAC production innovations in the manufacturing phase, the life cycle perspective should always be kept in mind.

2. THE AIRCRETE PRODUCTION PROCESS IN GENERAL

The success of an Aircrete AAC factory depends on its economical, technological and technical feasibility. Choosing the right manufacturing process is probably the most important decision in the product and factory's life cycle (Figure 2).



Fig. 2. Selecting the right production process

Detailed investigations must be carried out at the beginning for the market, geographical location, building culture, acceptance, raw materials, infrastructure, and last but not least, the product range. Because the technology can be seen as 'Alchemy', it is a must to produce pilots with local materials to ensure that there are no surprise and to better design proper plant formulas. A crucial impact on recent factories is energy consumption and waste percentages. Supplied energy, in the form of electricity and fossil fuels, should be kept at a bare minimum and CO₂ emissions negligible. Every factory is faced with the dilemma of reducing and reusing energy and other resources in compliance with increasing regulations.

3. WASTE TREATMENT

Waste can be divided into: green production waste, hard production waste (breakage from tolerance products) and recycle waste (from demolished buildings). Green waste is the green crust and rest material (semi-plastic) from cutting and casting with false mix cycles. This waste is somewhat easily remixed with production water to make a reusable slurry in the process. It is not yet feasible to produce without green waste, even though it is a loss of energy and resources. The challenge is for the producers to keep this percentage to a absolute minimum without compromises on quality. With hard waste, the matter becomes more complicated. Waste has a significant impact on the cost per m³ of AAC material itself.

Manufacturing Processes which have more, or structural waste should have a breaker crusher system to bring the material back to a suitable size for reuse in the process as a substitute for sand. This is a somewhat costly method as far as energy and equipment is concerned. Producers also elect to dump their waste into pits, facing the added cost of fines and questions about their sense of environmental responsibility. AAC factories will have to find ways to treat with hard waste in the challenge to develop "0" waste production. Recycle waste is the third type of waste that AAC producers must confront. Building demolition creates a significant flow of silicate-based material back to the producers which should be cleaned, sorted, separated, crushed and reused in the process again. It is the ideal cycle of resources and where the AAC Industry can gain an advantage over other building materials.

4. ENERGY EFFICIENT PRODUCTION

Producing Aircrete AAC is possible with a variety of technologies and systems. Choosing the "right" technology and appropriate processes for the production of AAC is the key to realizing a sustainable and successful production. However, these elements are directly related to the availability of raw materials and the requested end-product. The production process, with its individual machinery, must meet the requested capacity, quality and product range in a reliable way. Beside this, the Plant formula, energy consumption, use of resources (raw materials), labor and maintenance all have a serious impact on the cost per m³ (and environment). Analyzing and piloting new projects is therefore essential for further realization. In the next section we take the reader on a tour of a sustainable plant.

4.1. Raw materials preparation

Because the availability of raw materials is paramount in AAC production, the first step in the AAC manufacturing process is the preparation of raw materials. The type of sand, cement, lime and additives all have an impact on the preparation itself. While lime and cement are in most cases available in sufficient fineness, in nearly all cases, the sand must be ground to smaller and suitable particles. Grinding can be done dry or wet; simply categorized as wet grinding or dry grinding, each method having its advantages and disadvantages. Raw materials preparation is a high energy-consuming step so choosing the right raw materials processing process is critical for reducing energy consumption and ultimately for the success of entire production.

4.2. Dry grinding

With dry grinding (Figure 3), the sand must be dried in a special fluid bed dryer or in a fired grinding mill. Ground sand can also be combined with cement and lime to form a final homogenized meal product. The dried and grinded sand is stored in a silo before mixing. Final tuning of the formula is done in the mixer by adding solids such as cement, lime, gypsum, etc., and other additives. The main advantages are the precise casting temperatures, the low water/solids ratios, and non-continuous production (8 hrs/day, weekend stop). The process can handle different ambient temperature conditions (+45, -15°C), variations in raw materials and is less sensitive to power failures. The storage of grinded material requires no extra energy. A disadvantage is that the sand must be dried before grinding.

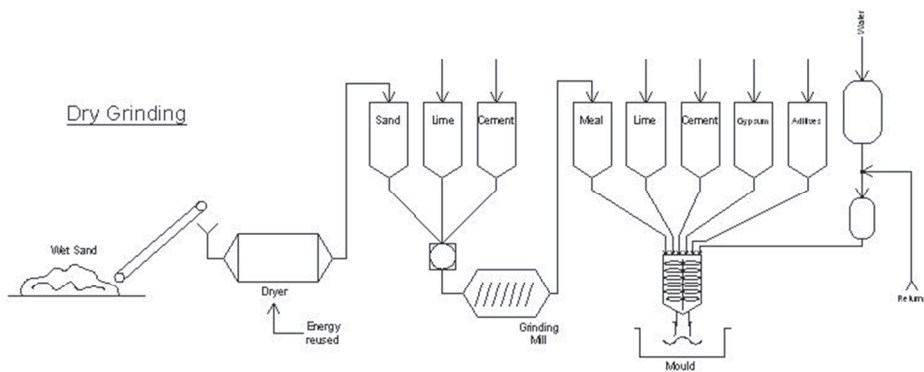


Fig. 3. Dry grinding

4.3. Wet grinding

Wet sand can be directly used with water in a Grinding mill. Due to fluidization with water, the transport in the mill is easier and the energy consumption somewhat less (figure 4). The wear of grinding material is a little higher than with dry grinding. Wet Grinding at its fundamental also seems easier because there is no need for drying the sand. The grinded sand is converted into a slurry with the highest achievable density at lowest viscosity. Certain minerals in the sand such as clay can have a negative impact on the viscosity and make the process unsuitable or difficult to handle. Attention must be given to the percentage formation of hydrogen due to the reaction of iron particles and the acidic environment in the mill which can cause a risk of explosion. Proper ventilation as well as the addition of a small amount of alkali to the mixture compensates for this. Sedimentation with non-homogeneity and sticking are the practical problems to overcome. Slurries must be continuously kept in suspension with agitators, and pumps should operate continuously to avoid blocked pipes; this consumes energy with no specific added value to the process. Because of the already high content of water in the slurry it is difficult to control the casting temperature because the quantity of control water is limited. In most cases, the fresh slurry must be heated to a suitable casting temperature; the effect however is a higher energy consumption. To treat with these process characteristics, the design, control procedures, cleaning, flushing, and the redundant equipment must be carefully planned. Good practice is to

run the wet grinding system in a “high frequency interval grinding” with minimum capacity in the slurry tanks. In such cases the energy of the hot, grinded slurry, often (50-60°C) can be used for the next step in the mixer.

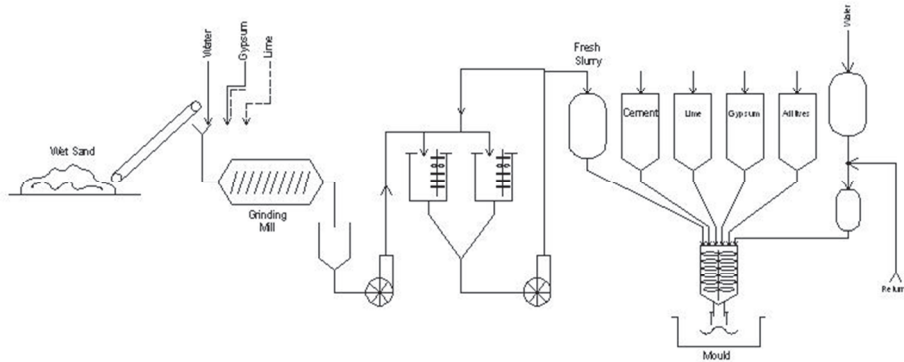


Fig. 4. Wet grinding

4.4. The grinding mill

Based on the available siliceous rock, sand or ash, the suitable grinding technology is selected. This could be the vertical impact roller mill, ball mill or a combination of mills. In many cases, the ball mill with modern drive best meets the requested output size. The sizing of a mill is an important factor in the AAC production process since it determines an upper limit for production capacity and constitutes a significant part of the energy consumption. The feed size and the Work Index of the input sand also directly affects these parameters.

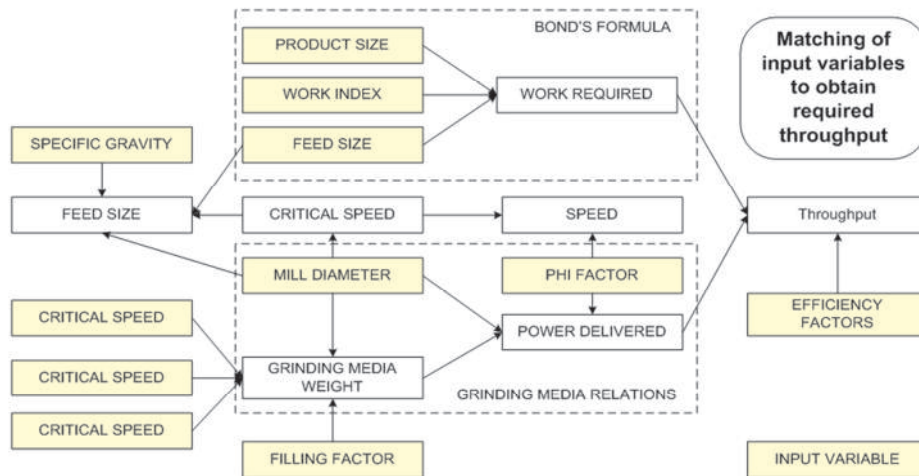


Fig. 5. The variables of a milling process

The optimal configuration of a ball mill based on the output requirements and the characteristics of the feed material should be analyzed for every application and

operational condition (Figure 5). Variables must be precisely analyzed before selecting and sizing the grinding technology and system.

4.5. Slurries

All Aircrete AAC factories must deal with slurries and its specific properties and handling difficulties. This could be the fresh return from green crust, Aluminum, Anhydrite, and pre-mixed hydrated lime. The slurry has a significant effect on the performance of a factory in the consumption of resources and waste.



Fig. 6. Aircrete Europe mass flow meter

The mass of solids and liquids is measured and related to densities by sampling or continuous measuring. The requested mass is measured by bins in weight, often with load cells. Aircrete Europe has designed a special mass flow meter for application in AAC production processes. (Figure 6). By using this device in an intelligent way, mass flow, volume flow, density, temperature and even viscosity can be measured with one device with accuracies up to 0,1%. With this technology, the accuracy of the process is drastically improved and is less sensitive to variations.

The plant design can be drastically simplified by eliminating the need for slurry weighing bins and all its peripheral equipment. The device should be integrated in the mixer control system as well as the slurry management system. The control system manages the quantity of slurry required in suspension and the formula is changed automatically depending on the available quantity.

4.6. Mixer process

The multi paddle mixer with an integrated CIP system (cleaning in place) is a significant energy saver in modern Aircrete AAC production. The energy consumption for an average 8 m³ multi paddle system is about 40 kW which is on average 50% lower in comparison with the high speed mixers. The multi paddle mixer also copes easily with both dry grinding and wet grinding technology. This type of mixer is suitable for the super light density blocks (<300 kg/m³) as well as the high densities up to 850 kg/m³ dry Aircrete AAC product. Due to its multi paddle design, the system is not sensitive to variations in filling degrees. The internal wear is negligible which results in many years of service with minimum maintenance. The mixer outlet has a special geometry for smooth flow with an integrated sieve and is coated with special PU coating to prevent dirt build up.



Fig. 7. Aircrete Europe multi paddle mixer

4.7. The cutting process

The cutting process is often seen as the heart of the process. Some cutting systems are referred to by their product brand name in the AAC market. Almost all cutting systems work with low-cost, high-strength steel wires and knives (Figure 9) for profiling purposes. The accuracies in building products has increased in the last decennia owing to the use of thin bed mortar and the precise thickness of wall products. In most building markets use of the thin bed joint has become the standard.



Fig. 8. (left), 9. (middle), 10. (right)

Oscillating, pneumatic, pre-stressed wires, working in opposite direction between 3 and 5 Hz give the advantage of better accuracy and lower cutting forces on the sensitive green cake (Figure 8). In comparison to the static wire, the oscillating wires reduce forces by 40% on the green product. The oscillating movements set the micro particles in a solid and smooth surface. The technology for high-speed cutting (10–30 Hz oscillation) with double wire for cutting and smoothening has become a standard in the product market for internal wall partitioning, fire protection and the prefab Casco buildings (Figure 12). Site savings in the form of less building time and stucco work for the contractors, as well as energy savings for the users by better insulation, are factors that can no longer be ignored. Panels, and even board for cladding purposes, can be cut very thin to 25 mm sheets. The US (Ultra Sonic) Hummer knife is an ideal technology to create the ideal surface with a thickened skin (Figures 10 and 11).

The new Cheese method of Cross cutting was implemented in the last 4 years. This method, with oscillating wires, reduces the cross cut time by 40%, improves the accuracy, and last but not least, reduces the green waste crust of casted green cake by

several centimeters. A 3 cm lower green cake from 68 cm saves 4,4% in resources and energy spillage which translates to big figures on a daily basis.

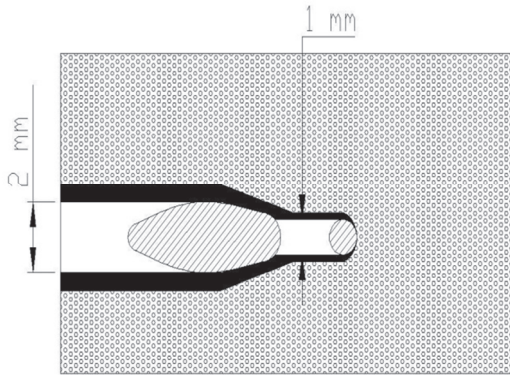


Fig. 11. Surface with compacted skin

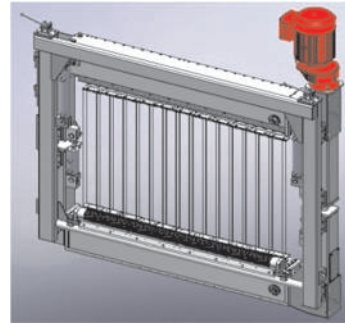


Fig. 12. High speed cutting frame

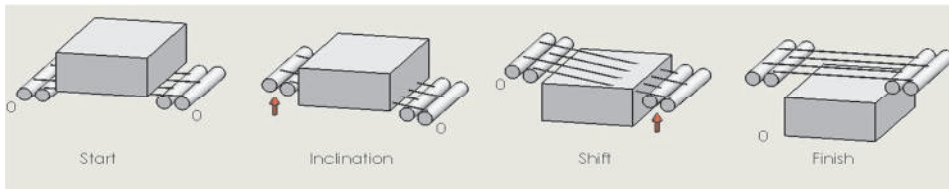


Fig. 13. The cheese cake method of cutting

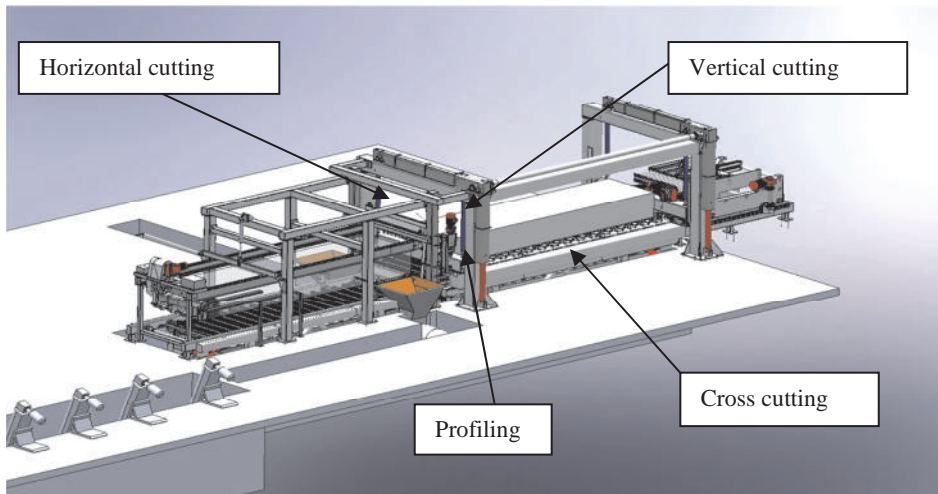


Fig. 14. All in one cutting system (Aircrete Versa Line)

A good working practice is that all cutting operations can be done in 1 machine to create the highest accuracy with no waste. This system requires no post-treatment to separate the green product from the hard (Figure 14). The green product is stable due to

the low point of gravity on a transport frame with carrying steel profiles and/or strips. The long cut opening, which is in most cases the sight view, will be 1 to 1.2 mm. This is an advantage for the later curing phase. Heat, in the form of steam, can enter the product with ease and has a positive effect on curing energy as well as curing time. It is good working practice to transport the ready green product directly in hot autoclaves or a pre-heated storage room to avoid cooling down.

4.8. Developments in reinforcement

Steel reinforcement is used for the production of partitions, walls, lintels, floor and cladding products. Load bearing products still need to have a coating on the steel to avoid corrosion in the alkali environment. Nowadays, mesh welding machines are available to produce a at high capacity and degree of automation for an economical value. Thin panels only have the long bars and the stretched sheet material.

A new development is the removal of the former needles to keep the cages in its position in the moulds during transport and pre-curing. Special clamping units keep the cages stable and rigid in position. This unique system saves a lot of work, cleaning activities and energy use, compared to older systems. Deep needle holes in the products, damage and the resulting waste created by needle pulling has virtually disappeared. Casco and Wall panels can be produced for dry building with “screw on” versions for mounting and dismantling.

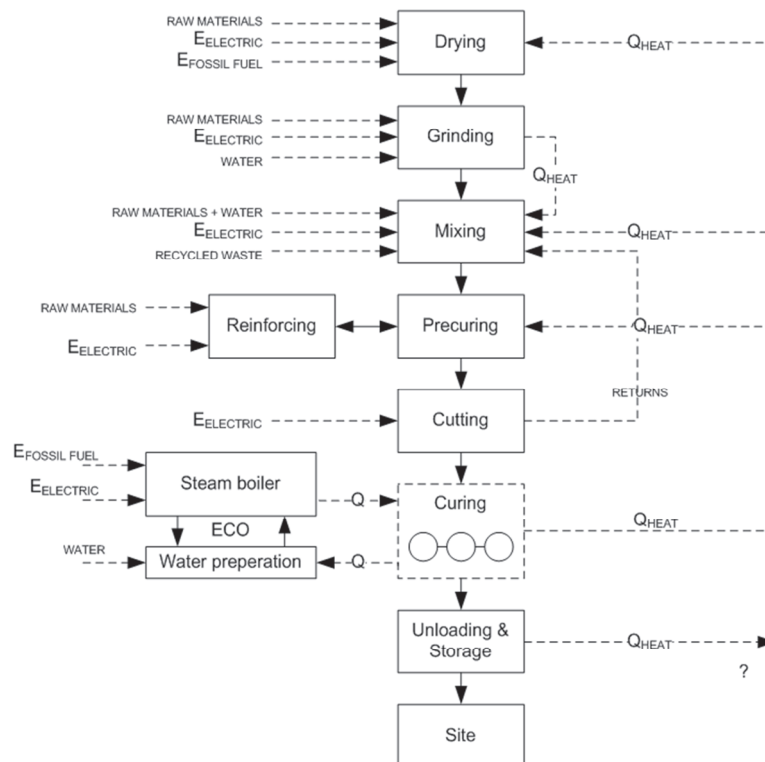


Fig. 15. Energy flow plan production line

4.9. Curing

The curing process is a costly and energy consuming part of the process. Often Boilers with a capacity over 18 t/hr of saturated steam are installed. Autoclaves with certain diameters and length are used for the curing process under a pressure of about 11-12 bar. With smart plant engineering, the energy can be effectively used and reused in the entire process again. Peak shaving of a boiler house is a very cost effective way to reduce energy consumption.

Steam transfer between the autoclaves, rest steam reuse, condensate heat and condensate reuse, and air heat reuse are areas where big savings (40%) can be realized and even the process itself improved. As previously mentioned, energy consumption has a tremendous effect on the cost per m³ of Aircrete AAC, and in most production plants, there is a significant potential to save on energy during curing. White smoke (steam blow-off), cooling down slurries, steaming condensate basins or releasing condensate flow insulation on equipment are areas to analyze for potential energy savings (Figure 15).

5. CONCLUSIONS

The reduction of waste and reuse of energy have serious potential for the Aircrete AAC industry to contribute to a sustainable future. Lean manufacturing based on a good fit between raw materials, technology and systems offers promising challenges for the producers to reduce cost. Modern production technology will support AAC Product developments to realize better, faster and so sustainable building.

Smart building is a new view on building and renovation with a strong relation to the lifecycle cost with the possibility to change, modify to regulations, or even a totally new reuse. Smart building is in the interest of producers, constructors and users. The call for more industrial building is increasing. Intelligent Aircrete AAC Board and Casco Panel products with smooth surfaces which can easily be reused, are key for the future in sustainable building. The need for available C2C (Cradle to Cradle) components is gaining sympathy every day. Let's work on this as an industry.