NEW CONCEPTS FOR FIBRE CEMENT PRODUCTION PLANTS

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ABSTRACT

The investment required for setting up a fibre cement production plant is relatively high in comparison to other building material production facilities. New concepts have been developed based on a modular plant design, which allow small start and continuous growth with the market. Plant capacities starting from 3 t/h can be extended to more than 10 t/h by adding equipment and handling systems.

Newly designed automatic handling systems provide a compact lay-out requiring a minimum of space so keeping the building size as small as possible.

Furthermore a flexible and modular arrangement of the individual sub plants is possible and the automatic handling system is also applicable for plant conversion in the fibre cement industry in existing factory buildings or on limited factory premises.

The new concept facilitates the addition of a press section without the requirement to modify the already installed equipment for non-compressed sheet production.

KEYWORDS:

fibre cement; plant layout; plant conversion; handling systems; modular plant; autoclaving

FIBRE CEMENT SHEETS –A VERSATILE- BUILDING MATERIAL

In today's markets fibre cement sheets are used for a variety of applications. Sheets can be found in form of flat or corrugated sheets. The sheets are either uncompressed or compressed in stack or single sheet presses. Some but not all Sheets directly exposed to harsh weather conditions are highly compressed. The main applications are:

- Roofing
- Exterior Wall Cladding
- Interior usage

The advantages of fibre cement sheets in comparison to other types of sheet materials are its strength, durability and cost effectiveness. Depending on climatic conditions, traditional building styles and cultural influences, the quality and properties of fibre cement sheets differ significantly around the globe.

It can be seen that the market for roofing products is shrinking, whilst flat sheets for exterior wall cladding and interior applications are becoming more important for the producers.

Producers look for niche markets, which require "value added products" such as surface treated facades. The requirements for surfaces and quality appearance have become more and more important and the market for mass products with low sales margin is not as important as it used to be in earlier times.

In consequence, products need to be specifically designed to meet the requirements of these niche markets. These market requirements have –of course- also an impact on the production process. Investors more and more look for plants with utmost flexibility designed in a modular way allowing modest start capacity, but with the ability to grow whenever necessary.

APPLICABLE TECHNOLOGIES

The terminology used in this presentation is related to the curing of the sheets. We distinguish between air curing (CC-Sheets) and autoclaving (CCA-Sheets). In the sheet forming process we can find two processes, the flow-on and the sieve cylinder process.

Basically the sieve cylinder process is the one which can be found in the majority of the production plants worldwide. The capacity of the sieve cylinder sheet forming process is significantly higher compared with the flow-on technology.

TECHNOLOGY FOR ROOFING PRODUCTS

Roofing sheets have to withstand harsh conditions. They are directly exposed to sun, rain, hail, snow and repeated freeze-thaw cycles.

For these products durability is the key quality factor. Experience has shown that sheets with lower porosity and higher density perform best. Mostly sheets are painted, not only for beautiful appearance, but also for sheet protection although air cured corrugated roofing sheets are mostly sufficiently impermeable in their own right.

Roofing sheets are commonly produced with air curing technology.

Air cured sheets are a composite of PVA and cellulose fibres, embedded in a matrix of mainly cement, and additive. The chemistry during curing follows the well known hydration process of cement. After a few weeks of air curing the sheets have gained sufficient strength. As normal during the hydration of cement, the matrix contains free lime. The free lime and also the CSH can react with Carbon Dioxide in the air and finally forms Calcium Carbonate

The carbonation process (aging process of the sheet) has a positive effect since the porosity of the sheet is reduced. The number and size of micro pores is reduced which reduced the risk that water can enter these pores. Consequently the durability of the sheet is even enhanced during the aging process of the sheet /1/.

TECHNOLOGY FOR FACADES AND INTERIOR APPLICATION

It is possible to produce these sheets with air curing technology as well; however for this type of application autoclaved sheets offer many advantages.

- Lower production cost due to the replacement of cement by finely ground silica sand.
- Better dimensional stability since the autoclaving forms a different form of crystallized calcium silicate hydrate (Tobermorite) which provides lower shrinkage rates.
- More flexibility due to higher fibre content in comparison to air cured sheets.

Autoclaved sheets are a compoite of cellulose fibres, cement and finely ground silica sand. The sheets are steam cured in autoclaves for 10-12 hours in a saturated steam atmosphere at temperatures around 180°C. Here the unique crystal structure is formed. The alkalinity (free lime) is significant lower than for air cured sheets.

Experience has shown that the aging process of autoclaved sheets is different in comparison to air cured sheets. In some investigations it has been concluded that the carbonation of crystallized and/or semi crystallized calcium silicate hydrate causes sheet shrinkage. Carbonation reduces the reversible moisture movement in air cured sheets, but increases it for autoclaved sheets. The shrinkage caused by decomposition of the CSH represents an important limitation to the universal use of autoclaved fibre cement. (Kalbskopf, de Lhoneux, Van der Heyden, Alderweireld (2002), Internal Wehrhahn R&D Report (2004).

CONSEQUENCES FOR FIBRE CEMENT PRODUCTION PLANTS

If we follow the above explanations, it is difficult for investors to produce a wide variety of sheets with the same equipment. Most companies use separate lines for roofing sheets and flat sheet production.

Considering the above explained facts, Wehrhahn has developed new plant designs for CCA production, to provide utmost flexibility and considering the modular concept to start small and to grow with the market.

The key features of the new concepts are:

- Installation of automatic handling systems in the plant. This reduces the required space and eliminates human errors in the manual handling.
- Possibility of adding a stack press whenever needed without changing the plant lay-out.

PLANT DESIGN AND OPERATIONAL PROFITABILITY

Due to physical limitations in layer thickness and felt speed the capacity of a sieve cylinder sheet forming machine with standard production width of around 1.2m is limited to slightly above 10to/h or 1200m2/h, based on 6mm sheet thickness. The investment for a fibre cement production line is determined by a base charge plus additional investment, depending on the plant capacity. The best operational profitability can be achieved by designing and operating the production plant near to the upper capacity figure.

However, to also open up smaller and developing markets the production line needs to start with lower investment and consequently reduced output capacity. To allow a later increase in production capacity WEHRHAHN has developed a modular plant concept for autoclaved flat sheet production that makes it possible to start small and to adapt later to developing markets by installation of additional equipment. The concept is such that no major modifications to the already installed components of equipment are required during the plant extension works and production disturbance is reduced to a minimum.

The WEHRHAHN modular plant concept allows not only capacity adaption but also the extension of the product range from uncompressed to compressed sheets by adding a press section to the already installed production line.

In the following the advantages of this modular plant concept will be shown in detail.

WEHRHAHN AUTOMATIC HANDLING SYSTEM (LOADING MACHINE)

The fundamental idea of the WEHRHAHN modular plant concept is connection of the individual sub plants by a central automatic handling system (loading machine) that replaces forklift transport within the production line. WEHRHAHN has gained vast experience with automatic loading machines that are an essential element of WEHRHAHN's AAC block production factories. The machines are characterized by

- Lifting capacity of up to 16 tonnes
- Travel speeds of more than 120 m/min
- Exact and smooth positioning
- High reliability
- Zero-emission electric drives
- Full automatic control

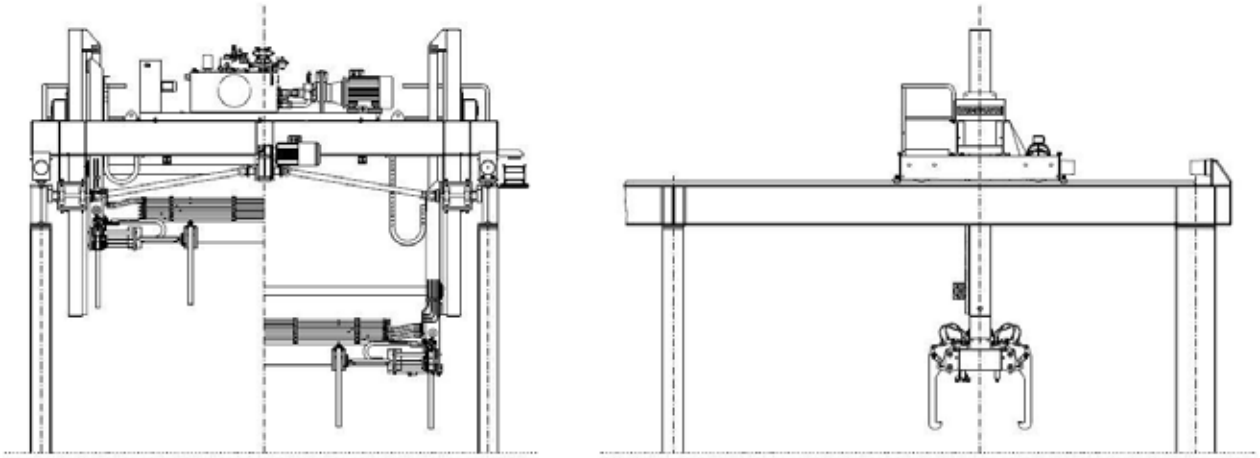

Figure 1 – loading machine for autoclave pallet transport within a fibre cement production line

The loading machine can handle autoclave pallets with green sheets coming from the sheetmachine to be transported to the precuring and autoclaving section and autoclave trolleys. It can manage all necessary transport around the autoclaves and replace the traditionally used forklifts and transfer cars.

In case of the production of compressed fibre cement sheets, the loading machine can also take over all required transport around the stack press. This includes picking up press pallets with green, uncompressed sheets from the sheetmachine, piling-up in front of the stack press and de-piling the press pallets behind the stack press.

PLANT LAYOUT COMPARISON

Classical plant layouts with forklift transportation

Figure 2 shows the layout of a typical fibre cement production plant for autoclaved flat sheets (CCA) with internal transportation of the sheets by forklift. The free area in the factory building is reserved for the later installation of a stack press section for the production of compressed flat sheets as shown in figure 3.

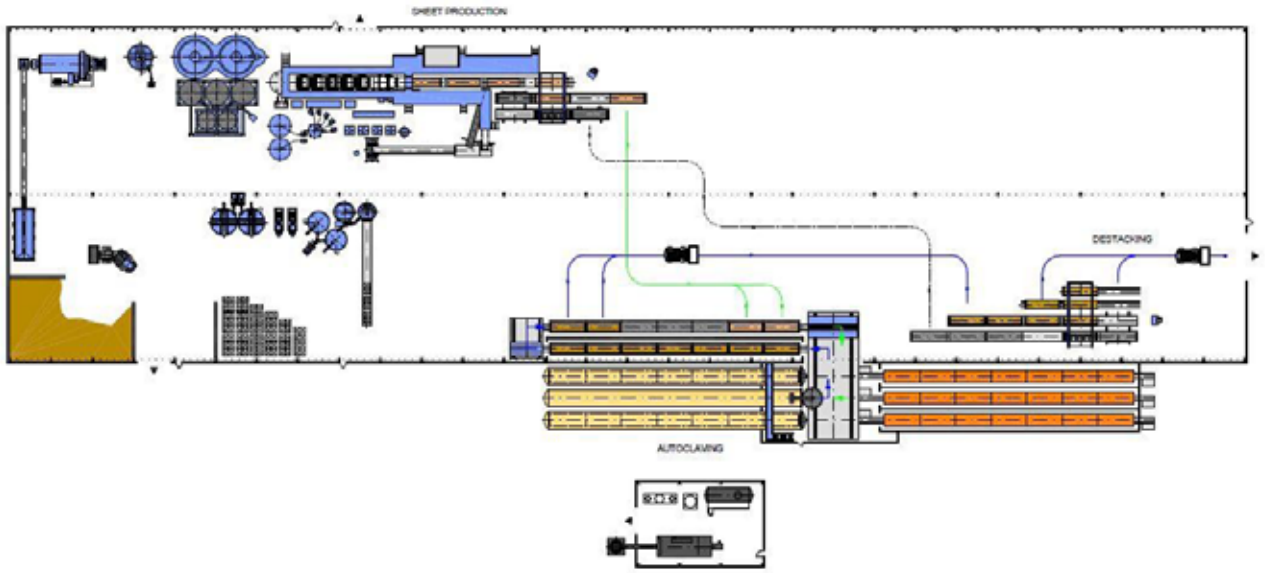

Figure 2 – plant layout with forklift transport, production capacity 10to/h uncompressed, extendable

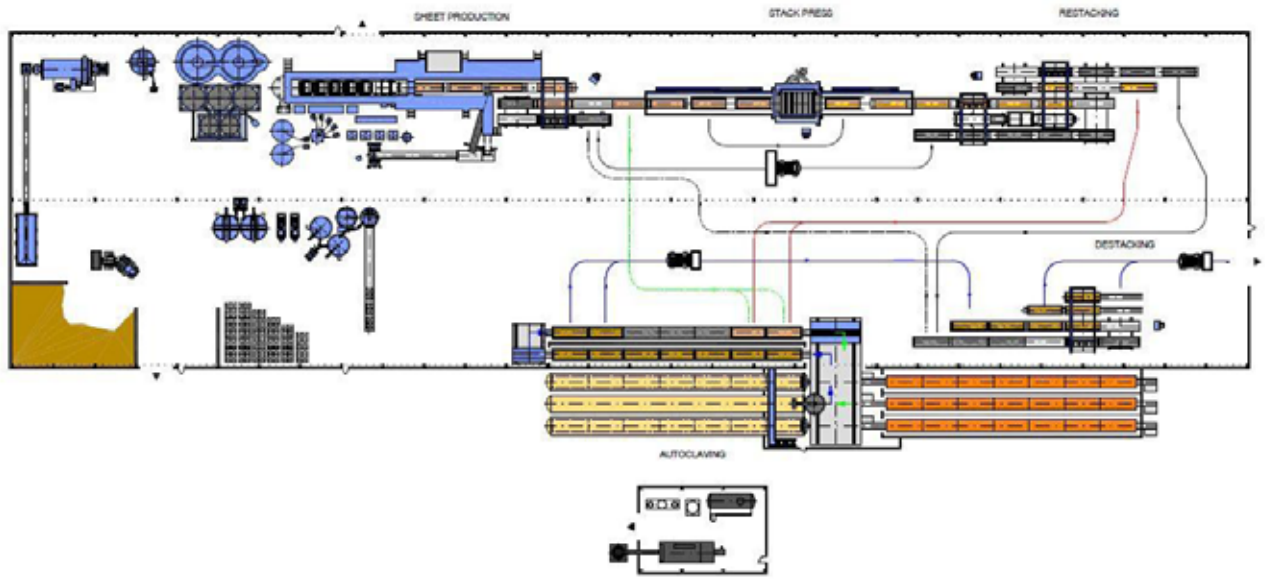

Figure 3 – plant layout with forklift transport, production capacity 10to/h compressed

The connections between the sub-plants “sheet production”, “autoclaving” and “destacking” are displayed by arrows which represent the necessary transport actions, to be managed by the forklift driver (cp. figure 2):

- Green sheets from sheet production to autoclaving (green arrow)
- Cured sheets from autoclaving to destacking (blue arrow)
- Empty autoclave pallets from destacking to sheet production (black arrow)

In case of the production of compressed sheets additional transport-jobs are required to connect the sub-plants “stack press” and “restacking” (cp. figure 3):

- Press pallets return from restacking to sheet production
- Press trolleys return to in front the press

To maintain a continuous production the forklift driver needs to fulfil all incoming jobs in time. A disturbance to the forklift can result in lack of autoclave or press pallets at the stacker discharging the sheeting machine and would finally result in a stop of the sheeting machine with all the typical problems of stopping and restarting the sieve cylinder process.

A plant layout with forklift transportation also requires the two charging cranes that are required to build the press pile in front of the stack press and separate the press pallets again behind the stack press. It will be shown in the following that WEHRHAHN's automatic loading machine can not only replace the forklift for internal pallet transportation but also these two charging cranes around the stack press.

Forklift transport needs big free spaces around the machines. Autoclave and press pallets are carried crosswise on the forklift. In case of long raw sheet formats of up to 5.0m it is a challenging job for the forklift driver to position the heavy transport goods smoothly and in exact position on the conveyor systems. Because of the required space around the machines the factory building area is two full naves of 24m width and 180m length, equal to 8600m^2.

In case the production of compressed sheets is not required then a more compact plant layout is possible as shown in figure 4. Here the required factory area is only approx. 4000m^2. Later extension to compressed sheet production is not possible with this layout.

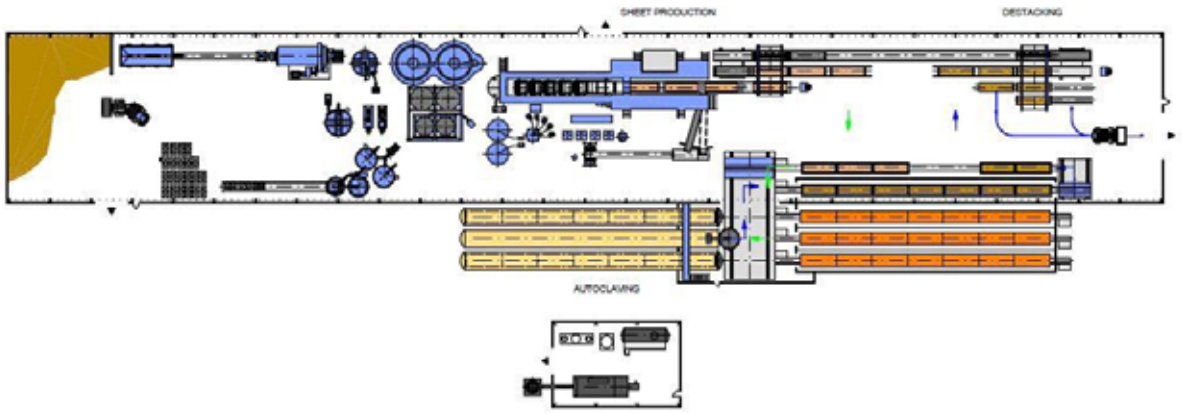

Figure 4 – plant layout with forklift transport, production capacity 10to/h uncompressed

New modular plant layouts with loading machine

The modular plant concept with automatic handling by a loading machine is ideal to start with a minimum investment and increase the production capacity later according to the market situation. Figure 5 shows a fibre cement production line with a capacity of 3to/h to 6to/h, a sheetmachine with 2 to 3 vats, reduced dosing- and mixing equipment and a small cellulose preparation, representing a minimum possible investment for initial production.

To keep the investment low, internal transportation is first realized by a forklift. For the comparatively low initial plant capacity this is convenient, because cycle times are long and only one autoclave is sufficient to cope with the output of the sheetmachine. As it contains only one autoclave rail, access is easily possible by the forklift.

For precuring the autoclave pallets are piled up inside heated chambers with roller gates. After precuring, the precured sheets can be loaded on the small number of autoclave trolleys to be ready for autoclaving.

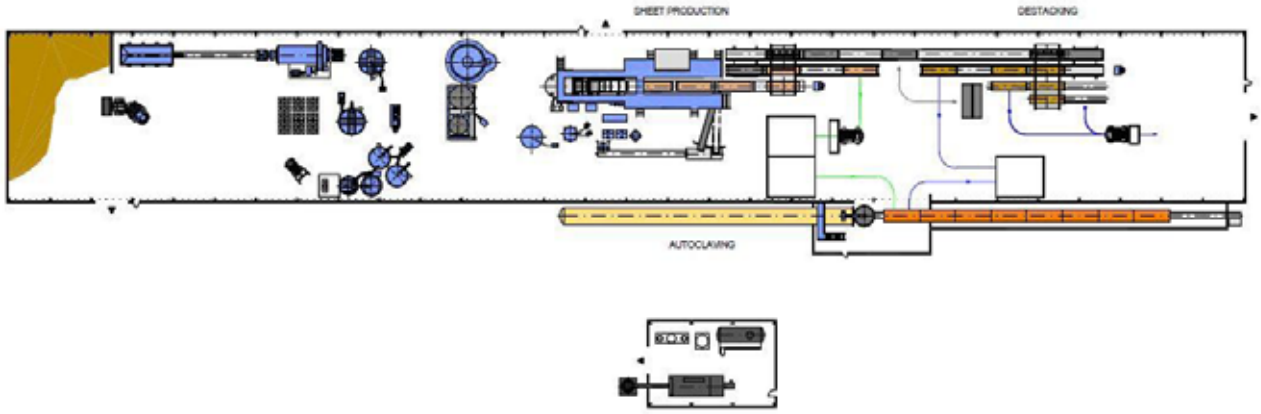

Figure 5 – plant layout with loading machine transport, production capacity up to 6to/h uncompressed, extendable

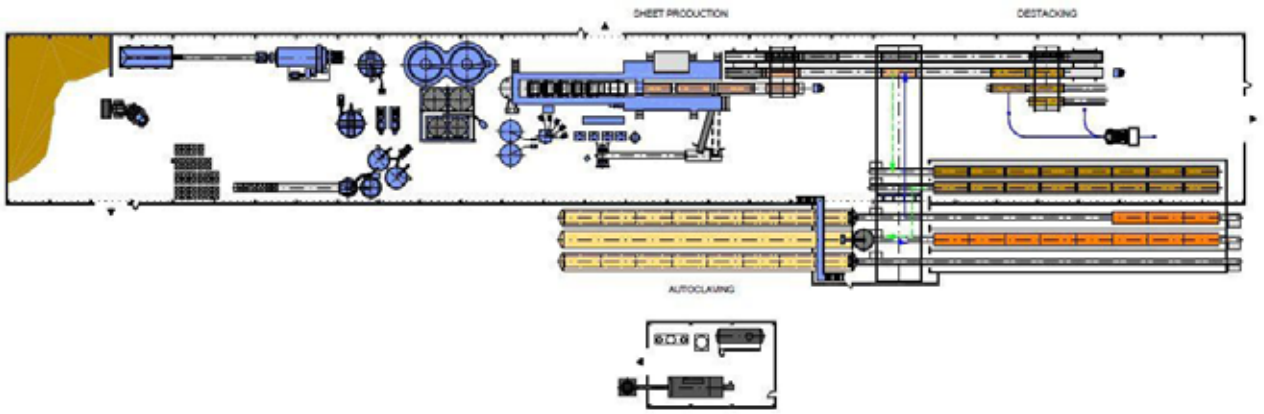

Figure 6 – plant layout with loading machine transport, production capacity 10to/h uncompressed, extendable

The plant is prepared for later installation of a loading machine to connect sheet production, autoclaving section and destacking. Figure 6 displays this plant extension to full capacity of 10to/h out of 5 vats. Additional cellulose preparation capacity and mixing equipment needs to be installed as well as two additional autoclaves and an automatic transport system in the precuring and autoclaving area.

Transport between sheet production, autoclaving and destacking is now realized by the loading machine. In comparison with the classical plant layout shown in figure 2 it can be seen that neither of the two transfer cars in the autoclave section is needed in the concept with loading machine, shown in figure 6.

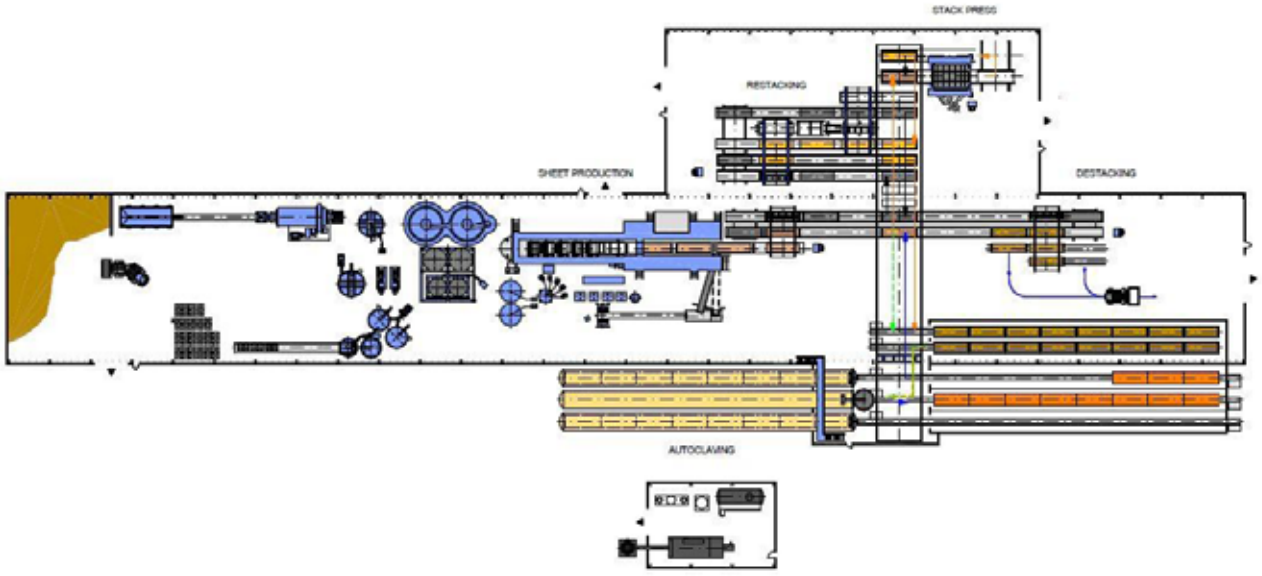

Figure 7 – plant layout with loading machine transport, production capacity 10to/h compressed

The last step of plant extension is given in figure 7. A press section with stack press and restacking system can be added to the existing production line just by extending the carriageway of the loading machine. This concept makes it possible to add compressed sheets to the product range without long production stops during plant modification.

For compressed sheet production green sheets are stacked on press pallets first. The loading machine transfers the sheets to the stack press. It replaces here the two charging cranes that are required in the concept shown in figure 3 to pile and de-pile press pallets before and behind the stack press.

After compressing press pallets are moved to the restacking system where the compressed sheets are arranged in autoclave racks to be kept for precuring and later autoclaving. The empty press pallets travel back to the sheetmachine by means of the loading machine.

In comparison to the classical plant layout with forklift transport shown in figure 3 the required factory building area is very small. The loading machine concept requires only 5600m^2 which is 65% of the area required with forklift transport.

Comparison of required areas for the factory building

Due to transportation by the loading machine in the new modular plant layout the required factory building area is considerably reduced.

Table 1 compares the building area of all the above described plant layouts. It can be seen that the modular plant concept with loading machine leads to savings in factory building costs by reduction of the building size of about 35%.

Table 1 – comparison of required factory building area

plant type	concept	cp. plant layout	product type	capacity [to/h]	req. factory building area [m^2]
forklift transport stack press extension possible	standard	fig.2	flat sheets non-compressed	10	8.600
forklift transport stack press	standard	fig.3	flat sheets non-compressed and **compressed**	10	8.600
forklift transport extension **not** possible	standard	fig.4	flat sheets non-compressed	10	4.000
forklift transport loading machine extension possible capacity extension possible stack press extension possible	**modular**	fig.5	flat sheets non-compressed	3 - 6	4.300
loading machine transport stack press extension possible	**modular**	fig.6	flat sheets non-compressed	10	4.300
loading machine transport stack press	**modular**	fig.7	flat sheets non-compressed and **compressed**	10	5.600

ADVANTAGES OF THE MODULAR PLANT CONCEPT WITH AUTOMATIC HANDLING SYSTEM (LOADING MACHINE)

The new modular plant concepts, based on connection of the sub-plants by an automatic loading machine offer many advantages in comparison with the classical arrangement with forklift transport. These are in particular:

Plant design flexibility due to modular arrangement of the sub-plants

The individual sub-plant modules such as sheet production, stack press and restacking section, autoclaving and destacking can be arranged freely along the carriageway of the loading machine by shifting or mirroring. Already existing components of to be updated plants or special arrangements of already existing factory buildings can be used and connected by the loading machine.

Including all positive features for new greenfield-projects mentioned above, the new modular plant concept can also be beneficial for

- Upgrade of existing factories
- Conversion of existing factories to NT fibre cement production

Later plant extension without major modifications on the already installed components

Additional equipment for capacity increase or extension to production of compressed sheets are mainly arranged around the start-up configuration of the plant. Therefore sheet production can continue during construction and installation works for the majority of the additional plant components. Regular sheet production only needs to be interrupted during commissioning and for a comparatively short period of time.

Minimum factory staff required

As transportation within the production line is fully automatic, the new concept plants require one worker less per shift compared with classical plants.

Low maintenance demand

WEHRHAHN loading machines travel on steel wheels along their carriageway, driven with frequency converter electric drives through toothed drive wheels. Grab lifting, opening and closing are hydraulically driven.

This construction leads to reduced maintenance effort compared with forklifts, running on rubber wheels and driven by combustion engine with torque converter.

As no additional transfer cars are needed in the autoclaving section, the overall maintenance demand for plant layouts with loading machine is comparatively low.

Less handling equipment to be installed

One loading machine replaces one to two forklifts and two transfer cars for a production line for uncompressed sheets (figures 2 and 6). In case of compressed sheet production additionally two hoist cranes can be replaced (figures 3 and 7).

Accordingly the overall investment for production lines for uncompressed sheets with loading machine concept is about the same as for the classical solution with forklift. Investment for compressed sheet production lines with loading machine concept is lower than for forklift transportation solutions because no extra hoist cranes are required around the stack press.

High operational availability

WEHRHAHNs automatic loading machines do not depend on the skills of any forklift drivers. Downtimes for maintenance are less than those of forklifts. In all, fewer different machines are required reducing failure probability. All three points lead to high operational availability of plants with loading machine transport.

Low foundation costs

Loaded autoclave pallets or press pallets can easily have a weight up to 8 tonnes. This requires heavy forklifts with related high axle loads. Foundations in the forklift travel area of the factory need to be dimensioned accordingly, usually executed as hard aggregate screeds.

For the loading machine concept only the columns of the carriageway need robust bucket foundations. Therefore foundation costs are reduced.

Smooth product handling and prevention from damages on transport equipment

Depending on the forklift driver skills, transport equipment in the pick-up- and placing positions of autoclave- and press pallets are exposed to strong impact loads in case of forklift access. WEHRHAHNs automatic loading machines with proportional hydraulic valves for grab lifting are capable of placing highest loads smoothly with exact positioning (see figure 8). Consequently product handling takes place much more smoothly and the danger of damaging the transport equipment is eliminated.

Figure 8 – WEHRHAHN loading machine during workshop assembly (left) and in operation (right)

CONCLUSION

In today's markets, buyers of Fibre Cement Production plants need a highly experienced partner, not only a machine supplier. WEHRHAHN has been designing Fibre Cement plants for more than 70 years and has experience in the wide variety of applicable technologies. A fully equipped laboratory and R&D centre is at the disposal of all buyers. Newly designed plant concepts offer the following advantages for investors:

- Flexible plant design due to modular arrangement of the sub-plants
- Later plant extension possible without major modifications on the already installed components

Smallest factory buildings due to compact plant arrangement

- Minimum factory staff required
- Low maintenance demand
- Less handling equipment to be installed
- High operational plant availability
- Low foundation costs
- Smooth product handling and prevention from damages on transport equipment

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