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I-PAN

INNOVATIVE POPLAR LOW DENSITY STRUCTURAL PANEL

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LIST OF ABBREVIATIONS AND DEFINITIONS

DoW	Description of Work
EC	European Commission
BD	Belt Dryer
HE	Heat exchanger
EA	Exhaust Air
CA	Circulation Air
OSB	oriented strand board
r.H.	relative humidity
kg	Kilogramm
kWh	kilo watt hour
ct	cent
VSD	various speed drive

1 INTRODUCTION

To be able to reduce the costs for drying OSB-strands, first you need to know where costs are produced and how they can be influenced. Stela has analysed the cost influencing points heat consumption and raw material losses (caused by damage of the strands). Another factors are the electrical consumption and the required spare/wear parts of the dryer. To create a basis for the comparison, also the requirements and cost reduction potential of the drum dryer is shown. Finally the results are shown in comparison to the state of the art technology for drying OSB-strands, the drum-dryer.

2 TECHNICAL REQUIREMENTS OF THE DIFFERENT DRYING SYSTEMS AND IT´S ADVANTAGES / DISADVANTAGES

Before the cost reduction potential will be evaluated, the different requirements in concern of energy, temperatures and emissions are shown.

2.1 TECHNICAL REQUIREMENTS OF THE DRUM DRYER

The drum dryer works with a low airflow but very high temperatures up to approx. 500 °C. By this, the use of low-caloric heat (secondary heat) is not possible. Instead of this, fossil fuel has to be burnt to generate the required hot air, the flue gases goes directly into the drying drum (direct heating). The generated hot air can take a lot of water per kg, but caused by the working principle the exhaust air temperature is still very high (>> 100°C). In view of emissions, the drum drier produces additionally to the flue gases from the combustion process of natural gas or diesel, also a lot of dust which has to be divided from the air by using filters and cyclones. As the air flow is relative low, the installation of filters and cyclones is a practical method to reduce the dust emissions. For cleaning of the flue gas, some models use an after-burning system to keep the amount of harmful substances low. Additionally to this and also caused by the high temperatures in the drying process, Lignin is spent. This means an additional pollution and could cause reduced mechanical properties of the final product, the OSB-boards. The required space is relative small, caused by the low airflow and the short retention times of the product inside the machine. This is also caused by the very high temperatures.

Figure 1: typical drum dryer

2.2 ADVANTAGES AND DISADVANTAGES OF THE DRUM DRYER

+ less required space because of low airflow and short material retention time
+ high water evaporation rates and by this big throughputs possible
+ low airflow makes the use of filters and cyclones for exhaust air cleaning possible, also the after-burning of the flue gases

- very high temperatures required → burning of fossil fuels necessary to generate these high temperatures
- thus high temperatures and direct heating also high risk of fire and explosion
- big emissions consisting of dust, lignin and flue gases requires exhaust air cleaning with cyclones, filters and after-burning systems
- hard to control drying process because of short retention time and undefined product ways inside

- high drying temperatures supports the building of volatile substances
- high exhaust air temperatures can not be used anymore, energy is wasted
- higher wear because of big rotating masses

2.3 TECHNICAL REQUIREMENTS OF THE BELT DRYER

In comparison to the drum dryer, the belt dryer works with high air flow and low temperatures of max. 120°C. This means in 99% of all plants, waste heat from other processes (ORC-process, CHP´s or production processes) in form of hot water or steam (secondary heat) is used. The drying air can take less water per kg, but through the high air flow the evaporation rate is the same. Depending on the final product moisture, the exhaust air temperatures are very low, so that no energy is wasted. In view of emissions, the belt dryer just produces wet air with a very low load of dust. This is reasoned in the facts that the air is sucked through the dryer belt, which is a fine woven polyester product, which is in combination with the product layer working as a filter. The air goes through from top to bottom and dust and fines stays in the product or belt. By this, no additional filters or cyclones are necessary to reach acceptable values (depending on the product less than 10 mg/m³ air). With the low drying temperatures, there is no respectively just very low evaporation or solving of volatile substances (VOC´s). The required space is big, but there is also the possibility to built up to 4 dryers above each other, especially if the drying air should be re-circulated. The control of the process is very good to realize, thus the long retention time there is always the possibility to influence it by changed airflow (the exhaust air fans are all VSD controlled) and/or changed belt speed (the belt drive is also VSD controlled). A moisture meter is directly connected with the control unit and changes parameters if necessary.

2.4 ADVANTAGES AND DISADVANTAGES OF THE BELT DRYER

+ high water evaporation rates and by this big throughputs possible
+ automatic filtering of the exhaust air by product layer and dryer belt means low dust emissions
+ no emissions in view of flue gases as no fossil fuels needs to be burned to heat the belt dryer (secondary energy is used)
+ very low risk of fire or explosion because of low temperature level and big air flow (lower or upper explosion limits are not reached)
+ low exhaust air temperatures gives a very good efficiency, no energy is wasted
+ by low drying temperatures no or less volatile substances (VOC´s) gets solved out of the product
+ different layouts possible, depending on the local requirements
+ easy to control, an equal final product moisture is reproducible
+ possibility for adjustments according to the changing requirements (fan speed, belt speed, height of the product layer)

- space requirements because of high airflow

3 EVALUATION OF THE COST REDUCTION POTENTIAL

In front of any action, an evaluation of the existing situation and the potential was done to set the right priorities and to set the target/limits.

As basic for the theoretical calculations an annual throughput of 172.800 tons of wet material was considered (21,6 t/h, 8000 h per year, input moisture 56,8 %, output moisture 3 %), what means a calculated average water evaporation of 96.000 tons per year.

3.1 COST REDUCTION POTENTIAL OF THE DRUM DRYER IN VIEW OF THE THERMAL REQUIRED POWER

By the fact that a drum drier needs a high temperature level, a use of low-caloric heat (waste heat, secondary heat) is mostly not possible. There are already after-burning systems for the flue gases available, to use the residual thermal power of the still hot exhaust air. Making this systems more efficient could cause in a reduction of the new generated thermal power and by this cost reduction. Another possibility could be to integrate the drum dryer in the overall layout to make a use of f.e. hot process gases possible. The drying process itself is more or less not suggestable, as the way of the strands is not defined but a product of random. So there is no potential to optimize and reduce the thermal consumption by this.

3.2 COST REDUCTION POTENTIAL OF THE DRUM DRYER IN VIEW OF MATERIAL LOSSES

In normal operation there a no important material losses, what comes in comes also out as the strands are conveyed by airflow and mechanical conveying devices which gets their functionality by rotation of the drum. The biggest potential is given by reducing the fire and explosion risk. If owners considers one fire a year as “normal”, the amount of wasted material and production losses is clearly visible.

3.3 COST REDUCTION POTENTIAL OF THE DRUM DRYER IN VIEW OF ELECTRICAL CONSUMPTION

In view of the electrical consumption the cost reduction potential is very low. There are some modifications possible to increase the efficiency of the drives, also the use of electric motors with efficiency class IE 3 or IE 4 is possible. But the relation between costs and effect is very poor, so that this is in our opinion more an action because of green thinking than because of real cost reduction potential.

3.4 COST REDUCTION POTENTIAL OF THE DRUM DRYER IN VIEW OF SPARE / WEAR PARTS

The biggest potential will be to reduce the risk of fire or explosion and by this the required spare parts. Also the equipment in front and especially after the drum dryer gets often damaged by fires or explosions, so that there will wasted a lot of money.

3.5 COST REDUCTION POTENTIAL OF THE BELT DRYER IN VIEW OF THE THERMAL REQUIRED POWER

With the standard air technology, that means all 5 fans are working as exhaust air fans, the heat consumption respectively the required heat amount looks theoretically like this:

ambient conditions	hot air temperature [°C]	exhaust air temperature [°C]	required thermal power [kW]
30°C / 70 % r.H.	95	48,15	12.000
10°C / 70 % r.H.	95	43,40	13.650
0°C / 70 % r.H.	95	40,00	14.800
-10°C / 70 % r.H.	95	39,10	16.100

Table 1: overview of calculated heat consumption with exhaust air only

The principle of the circulation air system is to reheat the one time used drying air of the last dryer part which is very low saturated, caused by the very low final moisture of the OSB-strands. From the theoretical side the following heat consumption respectively the required heat amount was calculated with 1 circulation air section:

ambient conditions	hot air temperature	exhaust air temperature [°C]	circulation air temperature [°C]	required thermal power [kW]
30°C / 70 % r.H.	95	48,15	48,0	11.950 (- 0,5 %)
10°C / 70 % r.H.	95	43,40	41,5	13.100 (-4,1 %)
0°C / 70 % r.H.	95	40,00	40,20	14.150 (- 4,4 %)
-10°C / 70 % r.H.	95	39,10	39,0	15.500 (- 4,3 %)

Table 2: calculated heat consumption with 1 circulation air section

As clearly visible in the tables, the effectivity decreases rapidly at high ambient temperatures.
This is reasoned in the decreasing temperature difference between ambient and temperature of the circulation air before passing the heat exchangers in the circulation air area. The maximum reduction is reached at an ambient of 0°C, as with decreasing ambient temperatures also the exhaust air temperatures decrease (because of lower r.H. after passing the HE and by this higher water absorption).

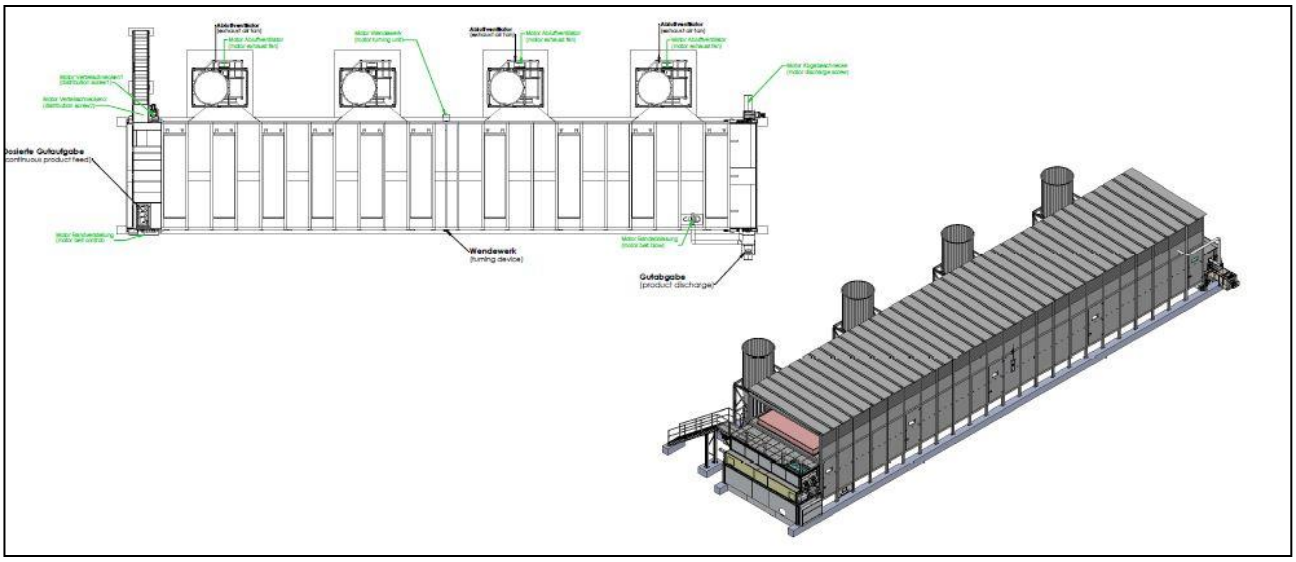

Figure 2: general layout of a belt dryer with exhaust air only

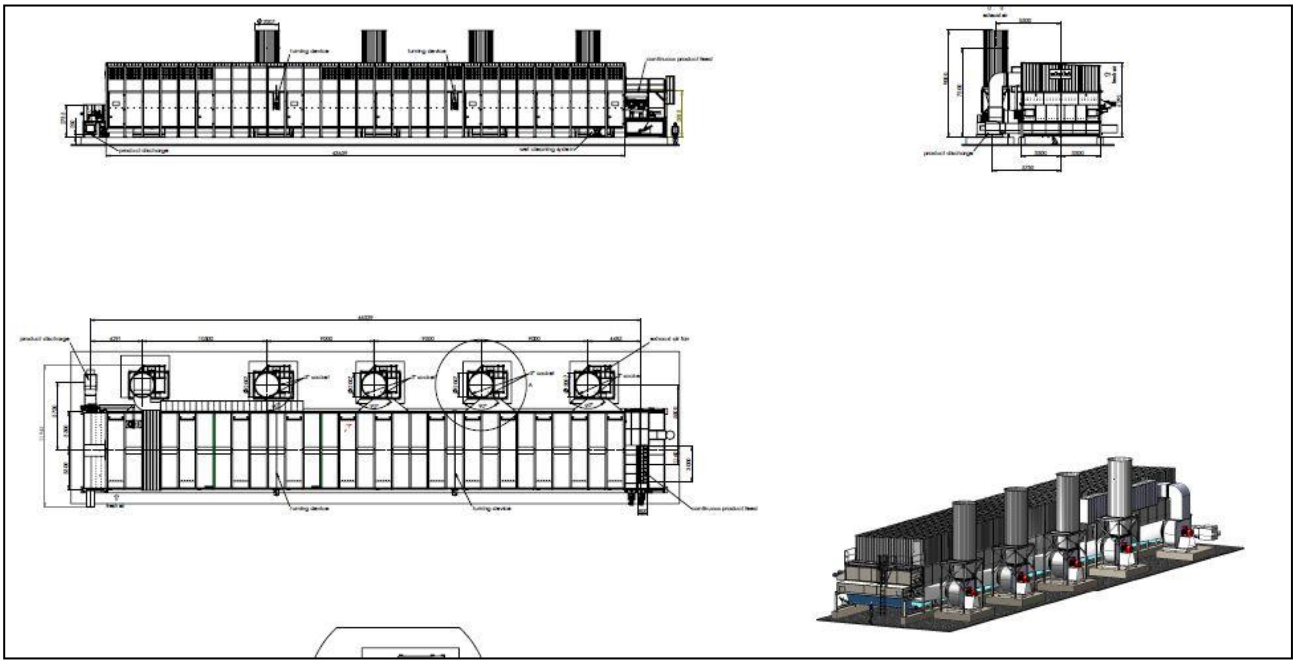

Figure 3: layout of the belt dryer for OSB-strands with 1 circulation air section

ambient conditions	hot air temperature [°C}	exhaust air temperature [°C]	circulation air temperature [°C]	input moisture [%]	output moisture [%]	through-put [t/h]	heat consumption [kW]
5°C / 85 % r.H.	79,60	59,40	82,83	56,0	1,38	12,0	7.105
30°C / 70 % r.H.	88,50	61,63	85,23	44,6	1,00	21,84	8.999

Table 3: real operation parameters of the belt dryer for OSB-strands

3.5.1 Comparison between theoretical calculated values and reality

In reality the measured values differs from the theoretical ones because of the following reasons:

- different product moisture at the inlet (caused by the different seasons, different storage time of the logs) and by this different drying curves along the dryer length → different temperatures of the exhaust/circulation air
- different hot water temperature and by this different hot air temperature → different temperatures of the exhaust/circulation air
- final moisture lower than 3% because of big differences at the inlet → different (higher) temperatures of the exhaust/circulation air

In fact, the real values differs by this single parameters and it´s combinations. The first line of table 3 shows the operation data without circulation air system, the second line with circulation air system. As clearly visible, the real data differs from the theoretical calculated ones because of the above mentioned reasons. The required thermal power for evaporation of one kg water was 1,069 kWh without circulation air system and 0,937 kWh with circulation air system. This means a reduction of 12,3 %.

3.6 Influence of the product layer to the thermal consumption / Effectivity

The two lines shown in table 3 differs also in the material distribution on the belt. Line 1 was recorded before modification of the feeding screw system. With the in the beginning installed distribution screw design respectively the screw through no proper and equal product layer on the belt was given (figure 3). The result is a non equal drying result and low effectivity as seen in the table. Line 2 was recorded after the modification of the feeding screw system (figure 4: modification works), the result was a much more equal product layer on the belt (figure 5) and by this an equal and effective drying process.

Figure 4: incomplete product layer on the dryer belt

Figure 5: modification works on the product distribution screws and screw-through

Figure 6: product layer after modification of the distribution system

3.7 COST REDUCTION POTENTIAL OF THE BELT DRYER IN VIEW OF MATERIAL LOSSES

The material losses of the belt dryer, caused by damage of the strands and by this waste, are close to 0 %. Especially caused by the extreme low final product moisture, fines are sieved out and accumulates underneath the belt. But this amount is in comparison to the handled material so little that a consideration is not possible. Also losses because of damaged strands are not existing as the product handling is very sensitive to the stands, so that there is no waste.

3.8 COST REDUCTION POTENTIAL OF THE BELT DRYER IN VIEW OF ELECTRICAL CONSUMPTION

In view of the electrical consumption the cost reduction potential is very low. There are some modifications possible to increase the efficiency of the fans, also the use of electric motors with efficiency class IE 3 or IE 4 is possible. But the relation between costs and effect is very poor, so that this is in our opinion more an action because of green thinking than because of real cost reduction potential.

3.9 COST REDUCTION POTENTIAL OF THE BELT DRYER IN VIEW OF SPARE / WEAR PARTS

After some problems especially with the design of the turning devices and by this necessary modifications no unforeseen required spare parts were used. The wear is by the low number of moving parts very low. So there is no further cost reduction potential given.

Figure 7: old turning device design (damaged)

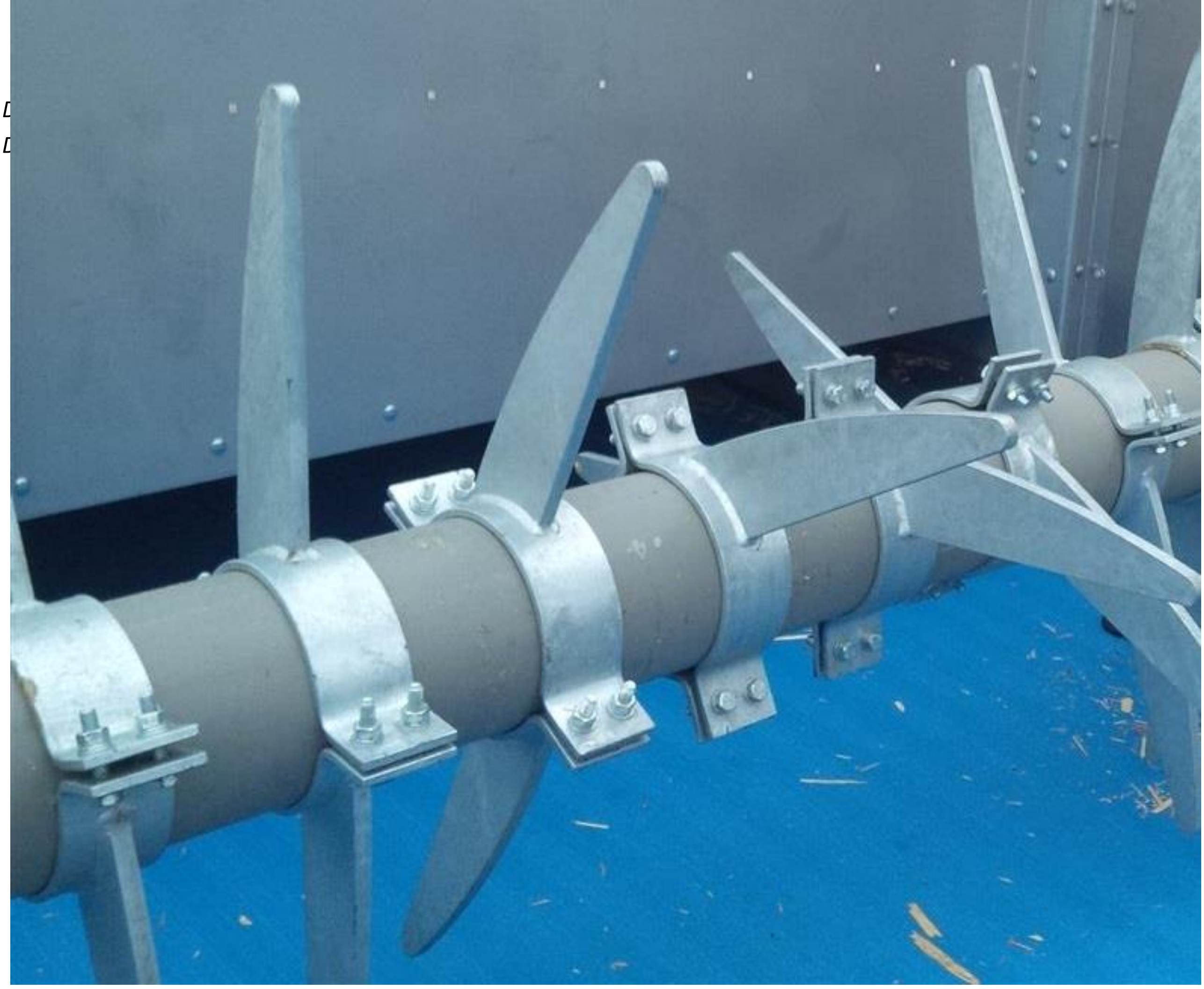

Figure 8: new turning device design

4 CONCLUSIONS

As basic for the evaluation, again an annual water evaporation of 96.000 tons (12 t/h) is considered. In this case, the cost reduction by using the belt dryer in comparison to the drum dryer is **4.494.913,60 € per year** as there are no costs for the thermal power existing. In summary, the comparison between the till now most common drying technology for OSB-strands, the drum-dryer can not compete against the belt-dryer if there is a waste-heat source existing. In most of the factories such sources are given, at least enough for a partial heat supply. In the following table the operational costs for thermal and electric power are compared. Not included are the investment costs as they are too much depending from the general layout and conditions. Also the insurance rates are not considered as this is also too much specific. Such items are just evaluated with the expected trend.

item	belt dryer	drum drier
costs for thermal power [annual]	0,00 €	4.492.800 €
costs for electric power [annual]	425.890,40 €	428.004,00 €
overall costs	425.890,40 €	4.920.804,00 €

Table 4: cost comparison of different drying systems concerning heat and power

- considered costs for thermal power for the belt dryer: 0 ct/kWh (hot water is waste heat from ORC process, ORC-process was built up because of green electrical power)

- considered gas price: 4,68 ct/kWh (incl. taxes, fees and allocations) source: https://www.bdew.de/internet.nsf/id/08C60239425D6995C125796B004652BC/$file/2013_01_Europ%C3%A4ischer%20Gaspreisvergleich_1.Hj.2013.pdf

- considered electrical consumption belt dryer: 403 kWh/h (fans on 100 % load, all other drives on 70 %)

- considered electrical consumption drum dryer: 405 kWh/h (95 % load of the electrical drives assumed)

- considered price for electricity: 13,21 ct/kWh; source:

http://de.statista.com/statistik/daten/studie/151260/umfrage/strompreise-fuer-industriekunden-in-europa/

4.1 EVALUATION OF THE COST-POTENTIAL OF ITEMS NOT DIRECT TO EVALUATE IN MONEY

item	belt dryer	drum dryer
risk of fire and by this caused material losses, production losses, damages, required re-investments	++	-
insurance rates (depending on the frequency of accidents)	+	-
possible additional fees because of CO_2 emissions	++	-
CO_2 emission	++	--
VOC emission	O	-
required space	-	+

Table 5: evaluation of items not to evaluate in money

++ very good
+ good
o average
- bad
-- worse