White paper - comparison of raw material dewatering/drying methods

1. Synopsis

Multiple wet processing technologies exist that result in the creation of high-moisture products as well as tailings facilities. Where scale and economics allow, operators dry their products using rotary dryers, vacuum filters, pressure filters and similar technologies. And innovative approach of non-thermal drying has been successfully tested on a range of different materials and found to be economical versus the alternatives. These main technologies are modelled for thermal efficiency and comparisons are made on CAPEX, OPEX and product moisture.

2. Rotary drying

Similar in design to a rotary kiln, a rotary dryer combusts a liquid or solid fuel and uses the resulting produced heat to dry material in a rotating drum. Lifting elements ensure good solid-gas contact. To ensure the product does not exit the process at too high a temperature the energy consumption and federate is controlled.

A supplier advertisement on Alibaba claimed a coal consumption of 9kg/t product for a set of operating conditions. This seemed very low, and a calculation was performed to verify/dispute this claim.

Table 1: Claimed operating conditions on the Alibaba advertisement.

Material	Silica Sand
Rate	40 tph
Initial moisture	20%
Final moisture	3%
Fuel	Coal (bituminous assumed)
Offgas outlet temperature	120 degC max
Sand outlet temperature	50 degC max

A model was developed in HSC Chemistry V7 to simulate these conditions. To operate the model properly, the following additional assumptions were made:
Coal chemistry = 67% C, 6% SiO_2, 4% Al_2O_3, 20% C_7H_8, 6.7% moisture, Rest minor elements.
Offgas oxygen content = 0%.
Thermal efficiency = 100% (zero heat losses).

The coal consumption is calculated as 20 kg/t product, or 15.2 kWh/t product.

Since this result is considered unrealistic, the offgas oxygen content was raised to 5% and the thermal efficiency of the combustion process decreased to ~70% by introducing heat losses. This increases the coal consumption to 29 kg/t product, or 22 kWh/t dry sand.

It should be noted that the only way these exit temperatures can be achieved in a reasonable footprint is with heat exchangers to recover energy from the exit streams.

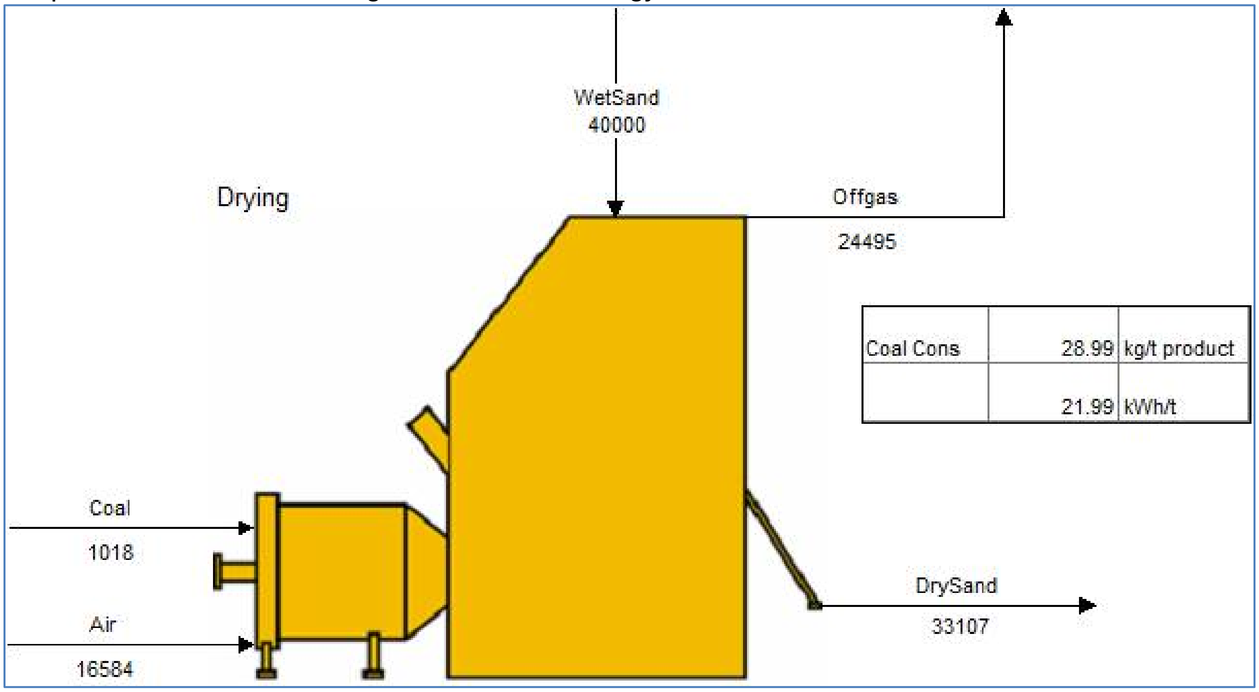

Figure 1: HSC model schematic - Rotary dryer - sand.

To further investigate this option some quotations were obtained. The claimed coal consumption was never resolved, with all responding suppliers claiming 8-10 kg/t sand, regardless of whether their rotary drier designs were conventional long kiln or triple pass. Their energy consumption numbers are thus ignored.

To operate all the equipment electrical equipment capacities totaled to 3.0 kWh/t.

Thus the total energy consumption is 29 kg coal (22 kWh/t) plus 3 kWh/t = 25 kWh/t sand.

3. Filter presses, belt filters and Disc filters

A paper presented by Hahn et.al. (J Hahn, 2014) discusses filter presses, belt filters and high performance disc filters for dewatering of gold/copper tailings at 100 tph following a conventional thickener >50% solids output.

It provides an excellent comparison on CAPEX, OPEX and product moisture for a copper concentrate. Highlights are given in Table 2 together with comparative numbers for other technologies.

A belt filter was also modelled based on independent data (Metso, 2011) to verify the electricity consumption, as shown in Figure 2. Data for a medium coarseness copper concentrate (80% passing 63 micron) was used to derive the required surface area, suction, air volume moved and required electricity consumption. The data and calculation results for a 10 tph plant resulted in a 14.4 kWh/t electricity consumption. This is much higher than the operational results tabled by Hahn for a 100 tph operating plant, and is deemed realistic based on the scaling of a vacuum pump versus energy consumption. As an example, by doubling the plant in size to 20 tph electricity consumption decreases to 12.5 kWh/t.

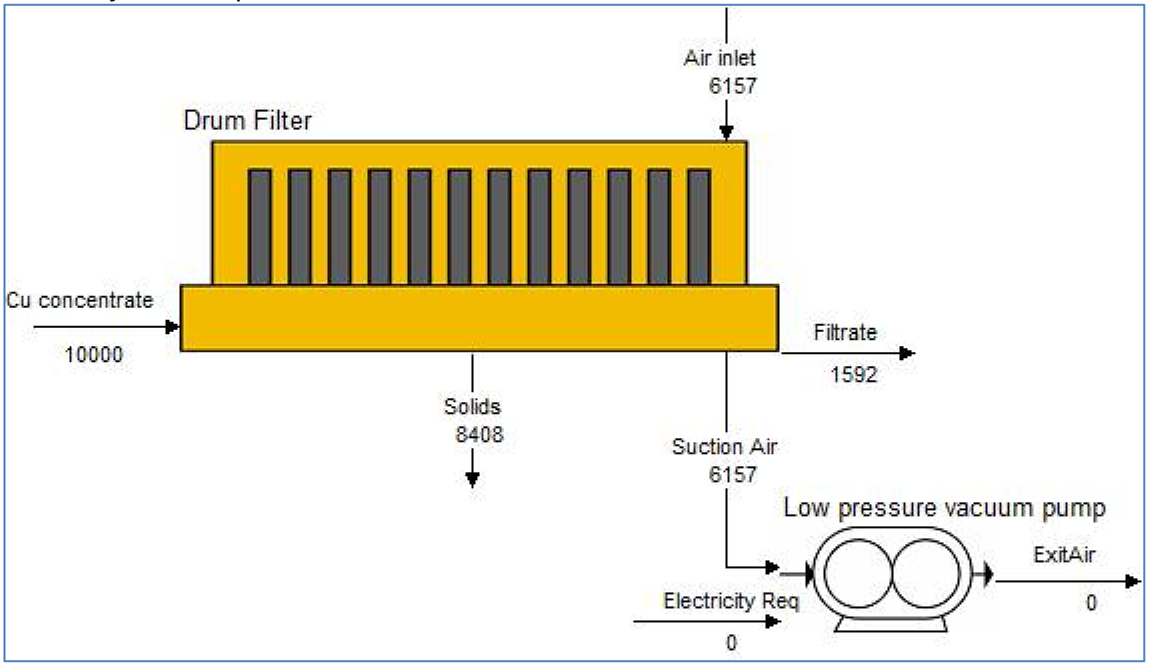

Figure 2: HSC Chemistry belt filter model schematic.

4. Non-thermal drying – BALF system

Bergaz LLC has developed a patented non thermal drying system using the principle of laminar flow to shear moisture from particles of dense material. The equipment used is a Boundary Air Laminar Flow (BALF) pump that is powered by a Roots Type blower. The moisture is separated by the cyclone and is exhausted as humid air.

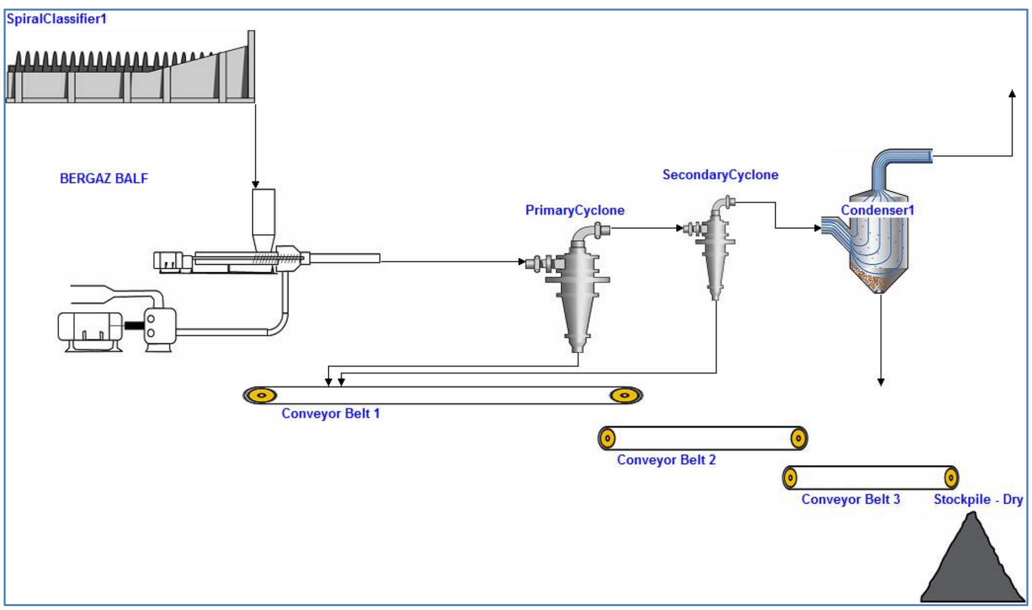

Figure 3: BALF system schematic.

Commercially used for 20+ years for transport and drying of glass, sand. garnet, coal and detergent the BALF technology has seen strong interest since 2014 for drying and/or beneficiation of iron ore, gold, copper, lithium and bauxite products and tailings, with various companies performing test work on their products/waste streams.

Results from one iron ore tested in 2017 showed moisture reduced from 35% to 8.0% in a single pass. Test work and modelling produced results that were comparable to other iron ore products tested, and a pre-feasibility level design confirmed CAPEX, OPEX and product moisture numbers to be very attractive. It should be noted that this result is not considered as normal, with a 10% moisture reduction in a single pass in larger, dense materials more representative.

A copper concentrate case for the BALF system was calculated from experimental data on similar materials to enable direct comparison to the Hahn paper. A concentrate of -100 micron was dried using a pilot plant facility from 35% moisture to 8.5% moisture. This was considered a worst-case scenario as an output from the wet processing plant. The resulting product moisture after free draining was still very high and incurred extra transport, ocean freight and end-user costs.

A second case was also calculated to reduce the product moisture down to 3% to make it comparable to the rotary dryer case. For economic purposes it was assumed that two BALF units in series would be required to perform this drying.

5. Comparative technical and economical analysis

Information from the Hahn paper, rotary drier suppliers, modelling and internal databases was used to collate the below table. For economic purposes the following assumptions were made:
Electricity price: AUD0.10/kWh.
Thermal coal price: USD106/t (February 2018).
CAPEX charge 10% per annual ton.

The comparison below shows that the BALF system can dry a concentrate for the same electricity consumption used just to rotate conveyors and a rotary dryer, with no need for an external fuel source like coal or natural gas.

Versus conventional dewatering technologies the BALF system also fares well, with lower CAPEX and OPEX, and if required a lower product moisture content.

Like conventional dewatering technologies, the BALF system only removes surface moisture, so high inherent moisture materials like coal cannot be dried down to 1% total moisture.

Table 2: Comparison between various technologies to dry a copper concentrate.

		Rotary Dryer	Horizontals belt filters x 5	One Boozer disc filter	One filter press	BALF system	BALF system
Moisture content in feed	wt%	20	50	50	50	35	35
Cake moisture content	wt%	3	19-22	15-18	15-18	8	3
CAPEX	MAUD	1.1	16.5	3.8	5.4	2	4
Power	kWh/t	3	3	3	4	2.5	5
Energy (coal)	kWh/t	22					
Operational hours	8000	8000	8000	8000	8000	8400	8400
Annual cloth cost	AUD p.a.	0	21000	43200	39000	0	0
Maintenance and spares	AUD p.a.	100000	60000	33000	90000	100000	180000
OPEX - electricity	AUD0.10/kWh	0.30	0.30	0.30	0.40	0.25	0.50
OPEX - coal	USD106/t	3.33	0.00	0.00	0.00	0.00	0.00
OPEX - cloth	AUD/t	0.00	0.07	0.14	0.12	0.00	0.00
OPEX - maintenance	AUD/t	0.31	0.19	0.10	0.28	0.31	0.56
OPEX total	AUD/t	**3.94**	**0.55**	**0.54**	**0.80**	**0.56**	**1.06**
CAPEX charge (10% per annualised ton)	AUD/t	3.48	51.56	11.88	16.88	6.25	12.50
TOTAL	AUD/t	**7.43**	**52.12**	**12.41**	**17.68**	**6.81**	**13.56**

6. Conclusion

Whilst not an exhaustive body of work, these few examples do illustrate the potential for this relatively-unknown BALF technology. All materials however are different in size and porosity, and a normal cautious approach dictates calculation of high level economics, followed by a staged test work program to verify potential. In all cases assessed since 2014 the BALF technology offered lower CAPEX, OPEX and end moisture.

Contact us to discuss high level economics and test work requirements for your materials.

7. Bibliography

J Hahn, R. B. (2014). Economical dewatering of tailings for mine backfill with high performance disc filters. *Mine Fill 2014*, (pp. 41-48). Perth.

Metso. (2011). *Basics in Mineral Processing - Edition 8.* Metso.