Hyperbar vacuum filtration

Combining pressure and vacuum filtration allows the use of rotary vacuum filters with the greater efficiency of pressure filtration. Greater solids throughputs and lower moisture contents are possible and cake drying is often eliminated.

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Continous vacuum filtration has long been considered a simple technology for process operation. In view of the great number of possible applications of vacuum filtration due to the use of different equipment (drum filter, disc filter, belt filter) made of nearly every possible material and owing to the extremely wide range of efficient supplementary techniques available (filter cake removal, washing, pressing, cake composition, filter cloth exchange etc.) this solids-liquid separation practice is nowadays one of the mos frequently used separation processes.

Vacuum filtration is adopted primarily in beneficiation plants (e.g. iron, non-ferrous ores, coal, etc.) where large mass flows have to be handled under severe conditions.

However, the greatest disadvantage of the vacuum filtration is the maximum adequate and technically possible pressure difference of Δp is only 0.8 to 0.9 bar. Consequently, the mass throughput is not only limited but in many cases the required residual moisture content cannot be achieved. This phenomenon is even intensified by the fact that there is a worldwide trend to the processing of ever finer particles.

Therefore, it is advisable to combine the advantages of the conventional, continuous vacuum filtration with the higher efficiency of pressure filtration, that is to carry out a combined vacuum-pressure filtration.

Hyperbar vacuum filtration

This technique is a vacuum filtration operated in the overpressure range. For this purpose, a normal rotary vacuum filter is completely insulsted in a pressurized room, vessel or chamber.

The filtration vacuum can be produced with a standard vacuum pump. In this way, a vacuum filtration is possible. For the performance of the hyperbar vacuum filtration the pressure tank is closed and compressed air is introduced. A tank overpressure of P<sub>oh</sub> = 1.5 bar then yields a filtration differential pressure of Δp = 1.3 bar. This is a vacuum if P<sub>oh</sub> = 0.2 bar act. below the filter medium in the filter cell whereas an overpressure of P<sub>oh</sub> = 1.5 bar prevails above the filter medium. The overpressure pressues upon the suspension surface so that the filter cake is formed and dewatered at a differential pressure of Δp = 1.3 bar.

The system of hyperbar vacuum filtration also allows, through the control head, the application of various differential pressures for cake formation and dewatering. In this way the cake thickness can be decreased by a lower vacuum and consequently be dewatered at maximum differential pressure.

The suspension is delivered by a slurry pump to the pressure tank. After the solids-liquid separation of the suspension three components are obtained which have to be discharged from the pressurized room:

Filtrate and air

The filtrate is discharged through the filter cell, the control head and the filtrate tubes into the separators. The air passed through the filter cake simultaneously escapes. The two-phase mix is separated in the separator.

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content improvement. In new plants almost closed gas circuits can be established by means of this filtration technique, so that the treatment of problematic products is possible.

However, the most important factor is the substantially improved residual moisture content. Within the scope of a cost/profit analysis, the advantages resulting thereby, such as costs of the thermal drying, lower transportation costs, fewer problems during the batch processing stages, clearly show the profitability of hyperbaric vacuum filtration. At an increase of the differential pressure to \( p = 1.8 \text{ bar} \), the water content of treated iron ore already dropped about 24 kilograms per ton of solids. In the case of thermal drying, this means, apart from the transportation costs decrease, a reduction of the energy consumption by about 4 kilowatt hours per ton of solids.

**Experimental equipment**

For the investigation of the physical operations during the hyperbaric vacuum filtration, a laboratory-type pressure/suction filtration unit with a filter area of 20 square centimeters was used. During the experiments, the suspension is fed from the bottom into a pressure-resistant filter cell. After the simultaneous increase of overpressure and \( 0.5 \text{ bar} \), the filter cake is formed on a usual filter cloth.

This equipment allows the simple and rapid determination of the drying diagram of a filtration product with a small suspension quantity within a short time.

To obtain suitable design data for this technologically uncomplicated but efficient filtration technique, which allow a reliable scale-up to the conditions of an industrial plant, a pilot plant was built with the assistance of Lurgi. During the design of this plant, special care was taken that no unesthetic conditions were created and only realistic component parts were used.

The flow sheet of the pilot plant, Figure 3, shows the arrangement of the supplementary plant items around the rotary filter. A conventional rotary vacuum drum filter with a filter area of \( 2 \text{ m}^2 \) serves as experimental equipment. This filter represents the smallest operational unit of a series of industrial units based on the same design. A filter cloth similar to the filtration product is based on the same design. A filter cloth adapted to the filtration product is used as filter medium (Tamperen 74-2310).

The filter is installed in a pressure vessel which is designed for a maximum overpressure of 4 bar. The suspension to be filtered and originating from the benefication plant is pumped from the agitator tank, arranged outside the pressurized room to the filter trough, whereby the density and flow rate are measured. After cake removal, the filtered and dried cake is continuously conveyed through a discharge device, being independent from the filtration process. After the solidification, separation, the two-phase mixture consisting of air and filtrate is delivered through the vacuum pipes into the separator and is there separated. The filtrate is discharged by barometric legs so that the filtrate flow can be measured. The air separated is sucked off by the vacuum pump. At this point, the air flow is measured and indicated in standard volumes. The overpressure necessary for the combined pressure/vacuum filtration is evolved by a compressor. According to the operating pressure to be kept constant, the compressed air flows through a control valve into the pressure chamber.

Figure 2 shows the opened pressure vessel of the pilot plant with a view of the drum type filter.

A test series on pilot scale was performed with sphalerite concentrate of the Moegen concentrator. West Germany. At
Meggan, a polymetallic sulphide ore is mined and upgraded by selective flotation of the very fine disseminated minerals (gala, sphalerite) from the pyrite and shale type gangue. The sphalerite concentrate contains about 57 percent Zn. The size distribution is as follows:

<table>
<thead>
<tr>
<th>Size, millimeters</th>
<th>Weight, percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.105 - 0.025</td>
<td>50</td>
</tr>
<tr>
<td>0.025 - 0.010</td>
<td>20</td>
</tr>
<tr>
<td>0.010 - 0.005</td>
<td>12</td>
</tr>
<tr>
<td>&lt; 0.005</td>
<td>18</td>
</tr>
</tbody>
</table>

The density is 4.22 grams per cubic centimeter, the specific surface (according to Blaine) = 11.163 square centimeters per cubic centimeter. The sphalerite concentrate produced, about 12.5 tons per hour, (dry weight) after thickening to about 60 percent solids content is further dewatered, using a drum filter with a section area of 45 square meters.

The pressure difference, measured at the inlet of the vacuum pump is 0.8 bar, the capacity of the vacuum pumps is 3,000 cubic meters gas per hour at 0.2 bar.

The filter cake with a moisture content between 12 and 14 percent is fed to a drum dryer, where the final moisture is reduced to below 8 percent to allow handling and shipment.

The filtration properties of this concentrate had been determined in the laboratory. Afterwards, pilot scale tests were made. The laboratory tests suggested use of a filter cloth Polynova PP 2886 which is made from Polypropylene fibres.

For the pilot plant tests, slurry with a solids content of 25 percent volume (58.4 weight percent) was used.

Figure 3 shows the residual moisture content versus the speed of rotation of the filter drum at various pressure differences between 0.8 bar and 3.8 bar. 0.8 bar being the reference test series of straight vacuum filtration. The tests showed that a pressure difference of $\Delta p = 2.3$ bar is sufficient to produce filter cake with less than 8 percent moisture content suitable for direct handling and shipment without thermal drying.

In the case of the sphalerite concentrate filtering in the Meggen concentrator, an economic comparison of these different methods was carried out. These three methods are:

- Conventional vacuum filtration on a drum filter, followed by thermal drying in a dryng drum (existing situation).
- Hyperbar vacuum filtration.
- Filtration by an automatic pressure filter.

As a basis of the economic comparison, a filtering plant with a capacity of 12.5 tons per hour was chosen, which corresponds to the actual production of ZnS.

Figure 4. Comparison of cost factors for different dewatering methods.

The existing situation is characterized by a two-stage process. Since the humidity of the filter cake after vacuum filtration is too high for further handling and transportation (thermal drying is a must). Accordingly, additional costs arise from fuel consumption for the dryer and energy consumption for the dryer and equipment for the gas cleaning circuit.

At the pilot plant tests with the concent