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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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Continuous vacuum filtration has long been considered a simple technology basic 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 most frequently used separation processes. Vacuum filtration is adopted primarily in beneficiation plants (iron ores, non-ferrous ores, coal, etc.) where large mass flows have to be treated 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 installed in a pressurized room, vessel or chamber.

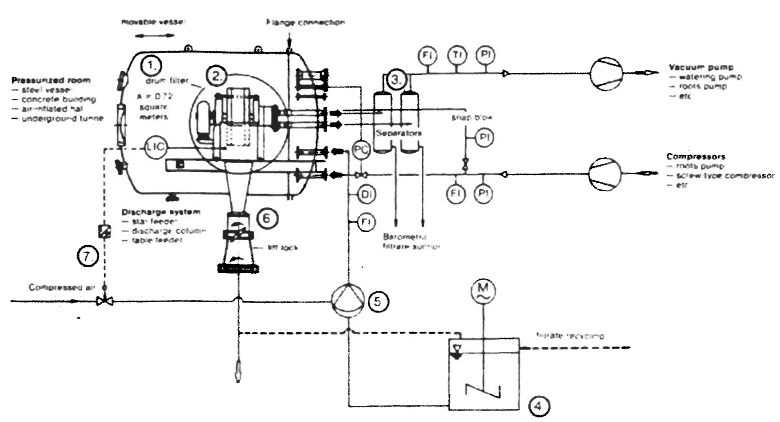

Figure 1. Flowsheet of the pilot plant for hyperbar vacuum filtration: 1) pressurized room, 2) rotary filter, 3) separator, 4) suspension tank, 5) suspension pump, 6) discharge system, 7) filling level measurement.

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_{abs} = 1.5 bar then yields a filtration differential pressure of Δp = 1.3 bar, that is a vacuum of P_{abs} = 0.2 bar acts below the filter medium in the filter cell whereas an overpressure of P_{abs} = 1.5 bar prevails above the filter medium. The overpressure presses 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 nevertheless 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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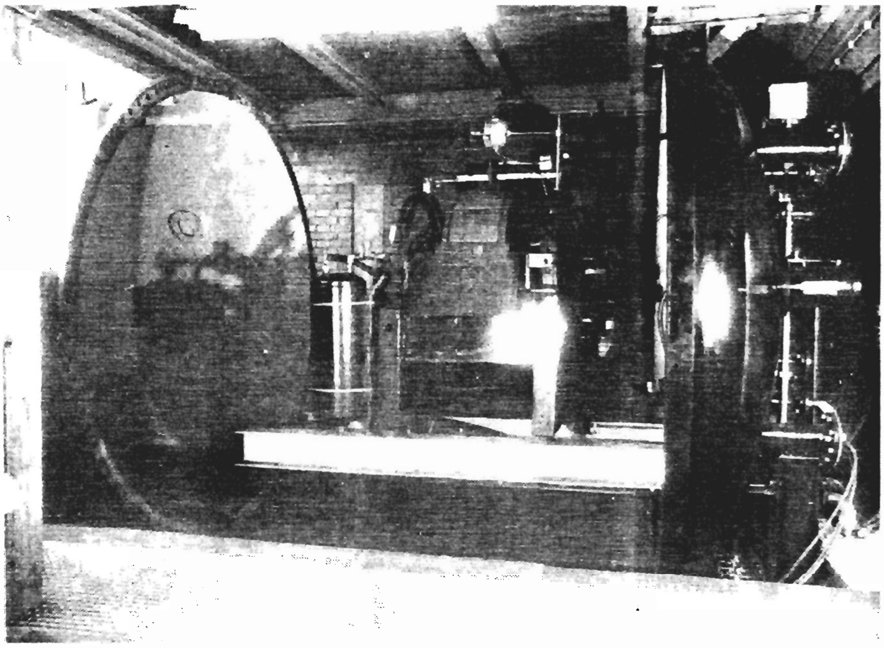

Figure 2. The pilot plant with pressure vessel open to show filter. In a full scale plant, an air inflated structure with an overpressure of about 1 bar would be suitable.

Moist filter cake

The previously suspended solids now consist of a cohesive and mostly abrasive bulk material, which is to be discharged from the tank by a suitable lock.

Hyperbar vacuum filtration offers the possibility of combining the advantages of pressure filtration with the mechanical advantages of conventional vacuum filtration. In this connection, the necessary overpressure can be considerably reduced by utilization of the vacuum filtration pressure difference. The moderate overpressure simplifies all the vital plant items of a hyperbar filtration plant such as pressure vessel, pumps and discharge device. The lower the overpressure can be kept, the lower will be the wear of the machines and the longer will be their lifetime.

For the practical operation, hyperbar vacuum filtration presents the advantage of a high plant flexibility since in the same plant both pure vacuum filtration and combined pressure/vacuum filtration, can be carried out. Apart from the cheap adaptation of the filtration method to the product to be treated, this fact is of great importance primarily for the start-up and shut-down of a pressure filtration plant.

Existing vacuum filtration plants can be adapted to hyperbar-operating conditions with plant items of the conventional vacuum filtration. Especially in plants operating at high altitudes (decrease of the vacuum filtration pressure difference), the superposition of the vacuum filtration with overpressure allows a very significant residual moisture 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 therefrom such as omission of the thermal drying, lower transportation cost, fewer problems during the further process stages, clearly show the profitability of hyperbar vacuum filtration. At an increase of the differential pressure to $p = 1.8$ 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 40 kilowatt hours per ton of solids.

Experimental equipment

For the investigation of the physical operations during the hyperbar vacuum filtration, a laboratory-type pressure/suction filtration unit with a filter area of 20 square centimeters was used. During the experiment, the suspension is filled from top into a pressure resistant filter cell. After the simultaneous rise of overpressure and vacuum, the filter cake is formed on a usual filter cloth.

This equipment allows the simple and reliable determination of the dewatering 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 unrealistic conditions were created and only realistic component parts were used.

The flowsheet of the pilot plant, Figure 1, shows the arrangement of the supplementary plant items around the rotary filter. A conventional rotary vacuum drum filter with a filter area of 0.7 square meters 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 adapted to the filtration product is based on the same design. A filter cloth adapted to the filtration product is used as filter medium (Tamperen 71-2510).

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 a beneficiation plant is pumped from an 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 dewatered cake is continuously extracted through a discharge device being independent from the filtration process. After the solids-liquid separation, the two-phase mixture consisting of air and filtrate is delivered through the vacuum pipes into the separators 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 produced 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 Meggen concentrator West Germany. At

Meggen, a polymetallic sulphide ore is mined and treated by selective flotation of the very fine disseminated minerals (galena, sphalerite) from the pyrite and shale type gangue.

The sphalerite concentrate contains about 57 percent Zn. The size distribution is as follows:

Size, millimeters	Weight, percent
0.105 - 0.025	50
0.025 - 0.010	20
0.010 - 0.005	12
< 0.005	18

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 suction 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 pump 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 plant 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 three different methods was carried out. These three methods are:

- Conventional vacuum filtration on a drum filter, followed by thermal drying in a drying 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 concentrate of the Meggen concentrator.

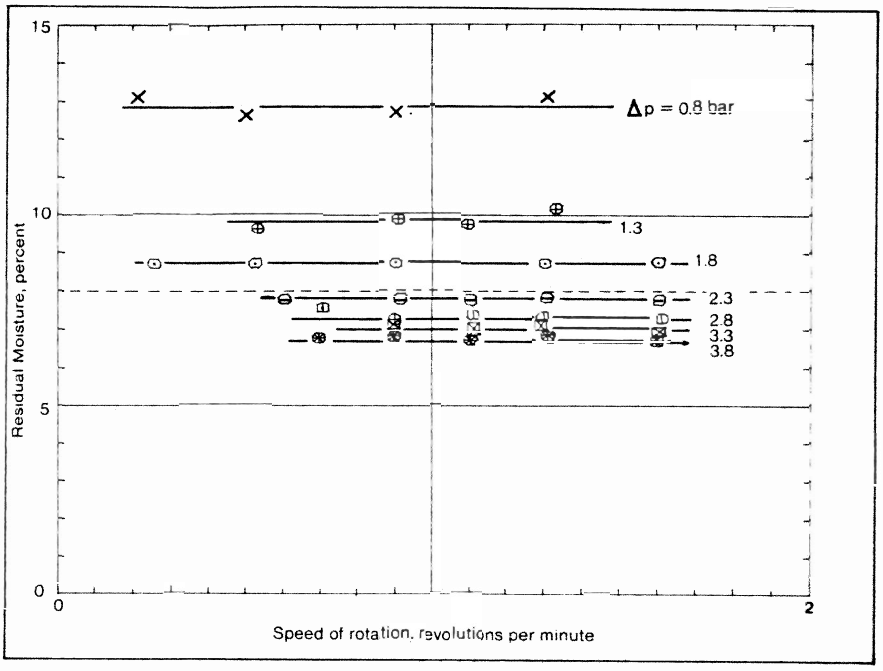

Figure 3. Residual moisture versus speed of rotation.

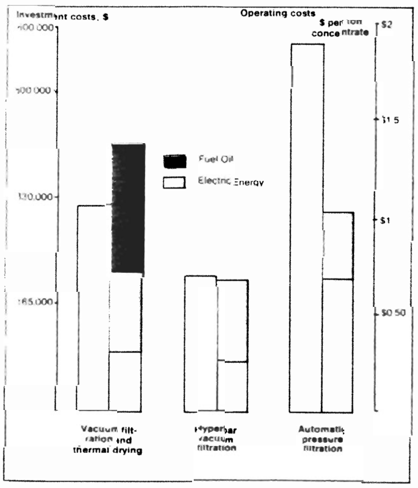

Figure 4. Comparison of cost factors for different dewatering methods.

The existing situation is characterized by a two stage process. Since 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 dryer and equipment for the gas cleaning circuit.

At the pilot plant tests with the concentrate have shown at a differential pressure of 2.3 bar, the residual moisture can be reduced below 8 percent. The higher specific throughput of hyperbar vacuum filtration versus normal vacuum filtration allows the use of smaller filtering equipment. The investment costs for the additional compressor equipment and the pressure vessel for the filter with the lock for discharging the filter cake.

The dewatering of the concentrate-slurry was also tested in pilot scale with an automatic chamber filter with an area of 2.25 square meters. Main feature of this filtering method is the cyclic operation. Filling of the filter chamber is followed by pressing the cake with a membrane, next step is blowing of pressurized air through the cake. In the final step the filter is opened, the cake automatically discharged and the filter closed for the next cycle. These type of filters are built in sizes up to 100 square meters filter area. For the sphalerite concentrate with 5.5 bar pressure difference of the drying air, a specific throughput of 200 to 250 kilograms per square meter per hour was determined.

Due to its design, the filter is heavy and the investment costs are high.

Furthermore, the cyclic operation of the filter necessitates for the auxiliary equipment (feeding pump for slurry, compressor for drying air) larger equipment than would be the case in continuous operation. ● IM 1985